A GUIDE TO PRODUCTIVE LIGHTING FOR INDUSTRY

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A Guide To Productive Lighting for Industry

REVISED AND ENLARGED EDITION

Compiled by

The Illuminating Engineering Department

BENJAMIN ELECTRIC MFG. COMPANY

DES PLAINES, ILLINOIS

NEW YORK CHICAGO SAN FRANCISCO

Table of Contents

Light Is a Production Tool that every worker uses every hour of the working day . . . .

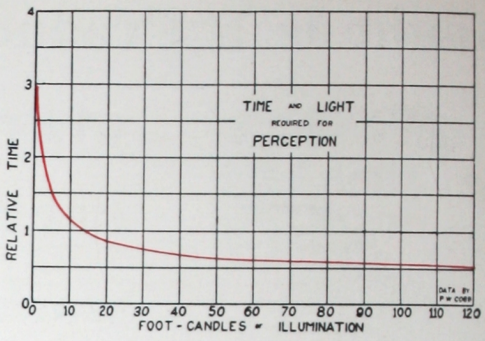
FROM the information window to the shipping room *light* is the *one* tool that every worker uses on every operation in the plant. It is a production tool; a basic factor of efficiency that aids management execute its vital program of lowering costs, reducing spoilage and increasing output.

Light is a tool for seeing; and seeing is fundamental to working. Seeing is so fundamental, in fact, that in the search for means to increase working efficiency it is often overlooked or taken for granted.

Three-fourths of the working movements of the body are controlled by sense of sight

FULLY three-fourths of the working movements of the human body are directed and controlled through the sense of sight. We move and act as we see. The speed and accuracy of working depends, to a large extent, on the worker's ability to see clearly at all times. But seeing is not instantaneous. The simplest act of sight requires a definite time interval—a period which is more than four times longer under poor lighting as under good. Like the camera, the eye must take time exposures when light is dim; and, likewise, the

human eye takes snap-shots, when light is good, with added clearness of seeing. The slower speed of seeing, with insufficient light, is strikingly shown in the accompanying graph. The simple perception of a black dot against a white background takes three and a half times longer under two foot-candles of illumination as under 100 foot-candles.



Poor light is the cause of eyestrain and bodily fatigue to workers

As seeing becomes slower and more difficult with poor light the thousands of separate movements of the working day slow up. Eye fatigue, caused by the continuous effort of straining to see, becomes a brake on working speed.

Glare and excessive contrast between brightly lighted sections and gloomy areas of the room are conditions which most often accompany poor lighting. Glare is usually the result of obsolete lighting equipment which allows the blinding light from the lamp to reach the worker's eyes.

In looking from intense light to areas of intense gloom the muscles of the eye contract and dilate violently, causing eyestrain, drowsiness and bodily fatigue to the worker. Glare and gloom are the evident symptoms of inadequate and obsolete factory lighting. They are the direct causes of lowered efficiency of workers and of loss of operating economy.

The contraction of the pupil of the eye to protect the sensitive retina from blinding glare takes place in one second—but it takes 60 times longer to expand again for normal seeing.

The effectiveness of light for seeing depends upon the lighting system

LIGHT is a tool for seeing, but management's control of this basic factor of production is possible only when lighting is incorporated into a carefully planned and correctly designed system. A factory lighting system is much more than the individual items of lamps, wire, reflectors and conduit. It is really the adaptation of this equipment to the specific needs and conditions of the workplace.

All the Year Around, Sunlight Averages Only 6 Hours a Day

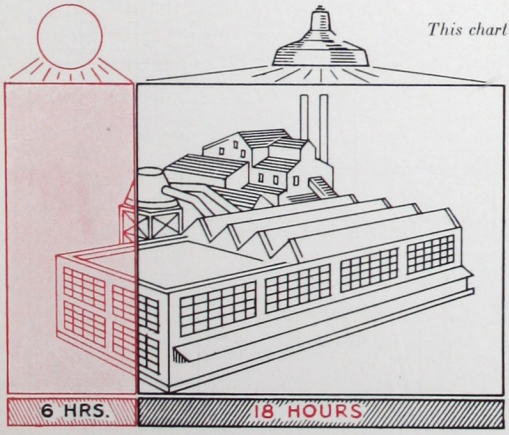
THE records of the United States Weather Bureau for thirty years back show that in latitude 40° an average of only 6.2 hours of sunshine per day can be expected. For most of the industrial sections of the country which are located north of 40° this average is considerably lower.

Daylight is inadequate for the demands of industry. Daylight fails often, unexpectedly, and completely; there are cloudy days, days of storm, the short days of Fall and Winter. Then all activity slows up unless adequate provisions for artificial illumination have been made.

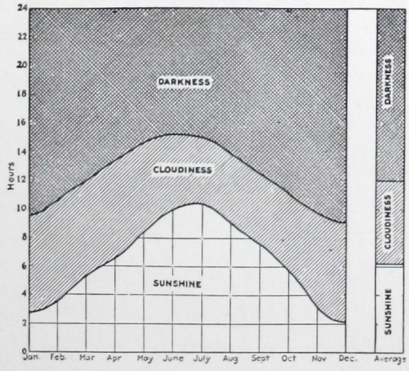
Thus in the modern one-story sky-lighted factory building, dependence upon daylight for illumination is a hazard. For even under the best conditions, natural daylight can be relied upon for only a relatively few hours of the day to give adequate light.

In all other types of buildings, even under the best conditions, daylight will not penetrate more than fifteen to twenty feet from the windows in sufficient quantity for work of an exacting character.

It is only when a plant is equipped with a modern and correctly designed system of artificial illumination that management is in a position to control light for seeing—so that under all conditions working efficiency is maintained at a uniformly high level.



This chart shows how little actual daylight we have over a considerable period of the year

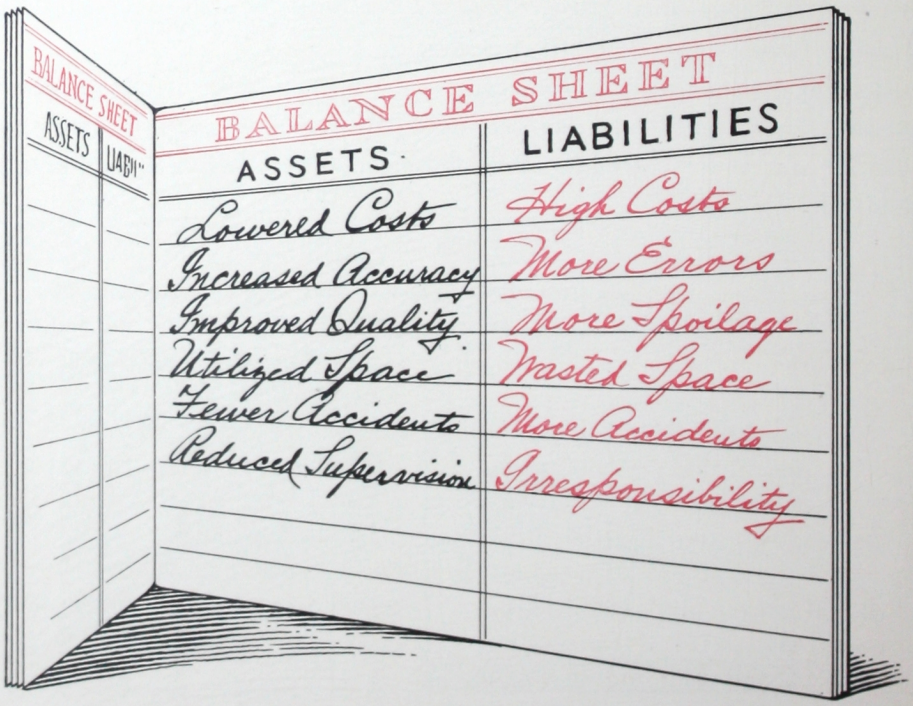


The Balance Sheet of Better Plant Lighting

MANAGEMENT may well ask, what are the balance sheet assets of better plant lighting? The plain facts of proved and measured performance are the answer.

Lower production costs, increased output from the same payroll, reduced spoilage, better utilization of floor space, lower accident rate, improved employee morale —these are the assets that definitely mark improved lighting as one of the most important single items on any betterment program. Operating efficiencies brought about by better plant lighting result from improving the worker's ability to do more and better work. Seeing better, men work faster and more accurately.

Just as an adequate system of lighting has definite balance sheet assets, so inadequate, obsolete and ineffectual plant lighting has its telltale liabilities. Mounting costs, lower quality of the product, increased errors, unproductive floor space, high accident rate and ineffective supervision most often have their roots in poor lighting.



Better Plant Lighting Improves Output and Lowers Costs

IN the report of the Committee on Recent Economic Changes, it is pointed out that, "intensities have increased, for it has been shown that such improvements have a direct beneficial effect upon production."

INSTALLATIONS OF ARTIFICIAL LIGHTING EQUIPMENT AND CORRESPONDING INCREASE IN PRODUCTION

Operation	Average intensity old system	Average intensity new system	Per cent increase in production	Name	Address	Business
	Foot-candles	*Foot-candles*				
Carburetor assembly	2.1	12.3	12.0			
Dispatching division	3.3	7.6	12.5	Post Office		Letter separating.
Final sorting	3.3	5.9	20.0	Post Office		Letter separating.
Grinding and machine work	1.2	6.5	13.0	Detroit Piston Ring Co.	Detroit, Mich.	Piston ring manufacturing.
Grinding and machine work	....	9.0	17.9	Detroit Piston Ring Co.	Detroit, Mich.	Piston ring manufacturing.
Grinding and machine work	....	14.0	25.8	Detroit Piston Ring Co.	Detroit, Mich.	Piston ring manufacturing.
Heavy steel machine shop	3.0	11.5	10.0			
Inspecting	43.0	55.0	42.0	American Pile Fabric Co.	Philadelphia, Pa.	Plush manufacturing.
Inspecting	5.0	6.0	4.0	Timken Roller Bearing Co.	Canton, Ohio	Roller bearing manufacturing.
Inspecting	....	13.0	8.0	Timken Roller Bearing Co.	Canton, Ohio	Roller bearing manufacturing.
Inspecting		20.0	12.5	Timken Roller Bearing Co.	Canton, Ohio	Roller bearing manufacturing.
Knitting	6.2	17.0	6.3	Reid Hosiery	Philadelphia, Pa.	Hosiery manufacturing.
Knitting	4.5	17.2	10.8	Philadelphia Sweater Mills	Philadelphia, Pa.	Necktie manufacturing.
Knitting (day)	....	17.3	3.9	Realart Silk Hosiery	Philadelphia, Pa.	Hosiery manufacturing.
Knitting (night)	7.2	17.3	5.75	Realart Silk Hosiery	Philadelphia, Pa.	Hosiery manufacturing.
Loom	10.0	13.0	15.0	American Pile Fabric Co.	Philadelphia, Pa.	Plush manufacturing.
Loom	3.3	10.0	16.0	Shenn Manufacturing Co.	Philadelphia, Pa.	Towel and wash rag manufacturing.
Loom	6.8	7.9	7.7	John Sidebotham	Philadelphia, Pa.	Tape manufacturing.
Loom	....	15.5	11.1	John Sidebotham	Philadelphia, Pa.	Tape manufacturing.
Loom (day)	1.9	3.7	1.85	M. J. Smith Belting Co.	Philadelphia, Pa.	Belting manufacturing.
Loom (day)	....	4.74	2.18	M. J. Smith Belting Co.	Philadelphia, Pa.	Belting manufacturing.
Loom (day)		9.66	3.22	M. J. Smith Belting Co.	Philadelphia, Pa.	Belting manufacturing.
Loom (night)	....	3.7	13.95	M. J. Smith Belting Co.	Philadelphia, Pa.	Belting manufacturing.
Loom (night)	....	4.74	16.75	M. J. Smith Belting Co.	Philadelphia, Pa.	Belting manufacturing.
Loom (night)	....	9.60	19.8	M. J. Smith Belting Co.	Philadelphia, Pa.	Belting manufacturing.
Loom	1.8	8.8	25.0	Taylor Brothers	Philadelphia, Pa.	Cotton dress goods.
Machine shop	3.4	8.7	3.0	D. B. Flower	Philadelphia, Pa.	Brass machine shop.
Metal shop	3.3	15.0	18.1	Decorative Lamp & Shade Co.	Philadelphia, Pa.	Lamp and shade manufacturing.
Pulley finishing	0.2	4.8	35.0			Pulley shop.
Soft metal bearing	4.6	12.7	15.0			Metal bearing.
Splicing	4.7	27.5	7.8	Matell Mills	Philadelphia, Pa.	Cotton spinning.
Turret lathes	11.6	20.0	12.35	American Metal Works	Philadelphia, Pa.	Radio and electrical goods.
Turret lathes	....	14.0	6.73	American Metal Works	Philadelphia, Pa.	Radio and electrical goods.
Turret lathes	....	7.4	2.35	American Metal Works	Philadelphia, Pa.	Radio and electrical goods.
Wire drawing	2.9	9.2	16.5	B. Wilmsen	Philadelphia, Pa.	Christmas tree ornaments.
Woodworking shop	4.5	25.0	20.9	Decorative Lamp & Shade Co.	Philadelphia, Pa.	Lamp and shade manufacturing.
	1.5	9.0	17.0			Jute spinning.
	0.7	13.5	12.2	Dover Mfg. Co.	Dover, Ohio	Manufacturing gas and sad irons.

Production increases recorded by representative industrial plants.

The above table reproduced from the Report of the Committee shows, for a group of manufacturing operations, the actual increases in the intensities of illumination provided and definite percentage increases in production obtained in every instance.

Such increases in production resulting in lower cost without additions to the payroll and in many other tangible and intangible savings are the result of modern high intensity lighting. As shown in the above table, this may involve increases of three to five times in the amount of light provided.

The expense of such an adequate system of industrial lighting, including the first cost of equipment and installation, maintenance, depreciation and operating expense, is in the majority of instances no higher than one and one-half per cent to two per cent of the annual payroll.

Better Lighting Cuts Down Errors and Spoilage

ERRORS, inaccuracies, poor work and imperfections often can be traced directly to inadequate lighting.

Poor lighting causes eye fatigue by the continuous effort of straining to see. Glaring, unshaded lamps in the field of the worker's vision and harsh, dark shadows on the work, strain men's sight and make it impossible to see. Then, hands guided by tired, aching eyes lose their skill and accuracy. Workmanship becomes slovenly and haphazard; and "rejects" eat into production schedules.

Because men see better and easier with adequate lighting, they work more accurately. Like keen-edged tools and precision gauges, good lighting is conducive to better craftsmanship. With adequate light workmen are alert. Often they are able to detect errors in work before large runs have been ruined.

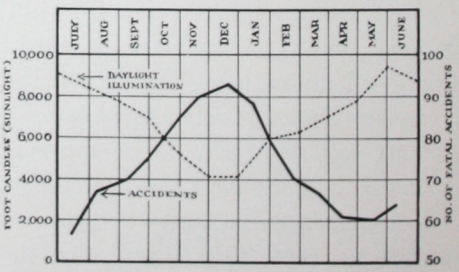
The quality of the work is maintained more easily and more consistently when the lighting system maintains the vision of the worker consistently. Adequate lighting enables men and women to use all of their energy to turn out quality production day after day—and do it with greater speed than ever before.

Better Lighting Lowers Accident Rate

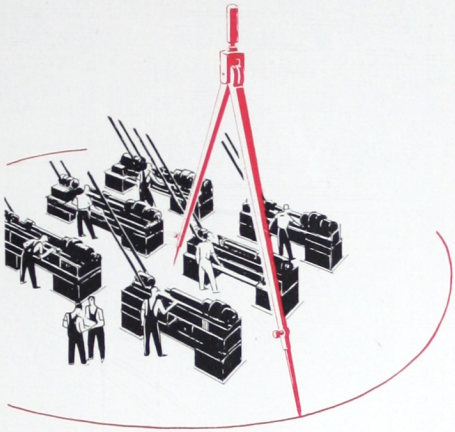
In a measure, a good system of industrial lighting is one of the greatest *safely appliances* of all. It prevents thousands of industrial accidents yearly, for upon a workman's ability to see depends his safety. When he sees danger plainly, he can usually avoid injury.

Only adequate plant lighting can give management protection against the uninsurable losses attending accidents. Good lighting is a powerful preventative measure.

The accompanying graph shows conclusively the relation between the industrial accidents and light. The accident rate increases sharply during the dark months of Winter, when inadequate systems of artificial lighting fail to meet the demands of industry.



Better Lighting Widens the Circle of Useful Floor Space



A PRODUCTIVE lighting system gives the same useful light at the machine or workbench as at the windows. In the far interior of departments and in out-of-the-way corners the light on the work is soft, clear and uniform. Dark sections of departments commonly used only for material storage are converted by uniform lighting to useful spaces suitable for any production. Greater plant output without expansion becomes possible, and crowding of machines and benches in daylighted sections of the plant is relieved.

Straight-line-production flow is more easily accomplished with the aid of modern industrial lighting. For the uniform quality of the working light in all sections makes possible the arrangement of machines for a minimum of material handling.

Improved Lighting Raises Employee Morale and Lowers Supervision

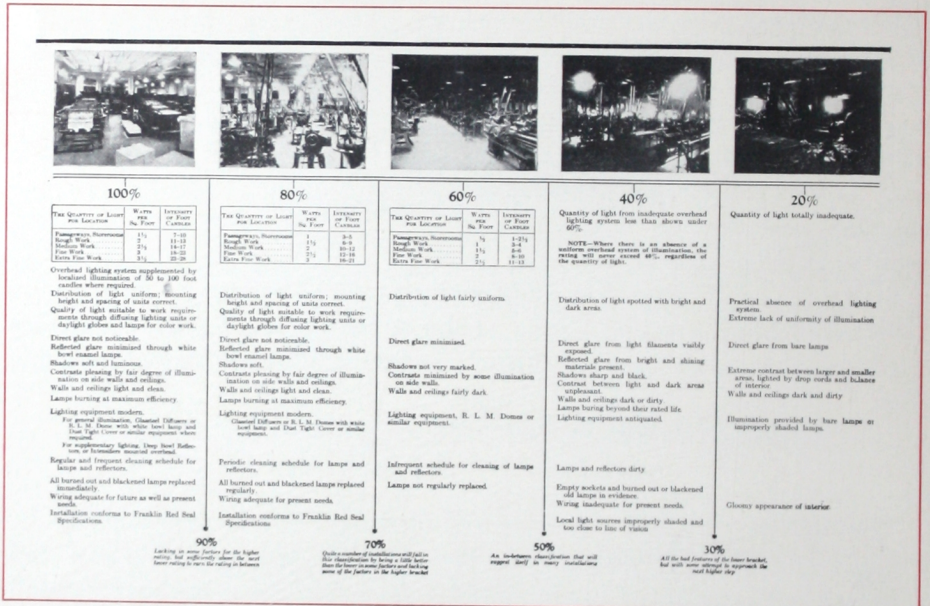
A DARK, dingy and gloomy shop is depressing to the people forced to work in it, while the well-lighted shop, with its bright and cheerful surroundings, makes for cleanliness, loyalty and co-operation.

Light stimulates activity; twilight and darkness make for relaxation and repose. Throughout nature, light is synonymous with life and energy, while darkness breeds carelessness and lowered efficiency.

Adequate lighting simplifies the problem of supervision. With dark corners eliminated and workrooms always lighted at an adequate level of illumination, supervisors are able to increase their own effectiveness of instruction, supervision and stimulation. The tendency for workers to loiter and shirk in dark corners is decreased.

How to Determine if Your Present Lighting System is Adequate

A CHECK-UP is the only way to be sure that all of your employees are working under favorable conditions for seeing everywhere in the plant and at all times. If you do not know positively that your present lighting is as good as it could be and that it is in condition to show up gains and not losses on your operating statement, then go through every floor and department in your plant and look for evidences of poor lighting as shown on this and the following pages.



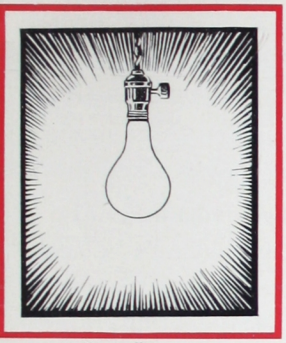
Use This Benjamin Rating Scale For Your Lighting System

You can quickly learn the trouble about your lighting system if you know what conditions to look for and what they signify. With the use of the rating scale devised by Benjamin Illuminating Engineers and shown in the reduced facsimile above, you can quickly estimate the approximate efficiency of your lighting system and express the result in a definite and comparable value.

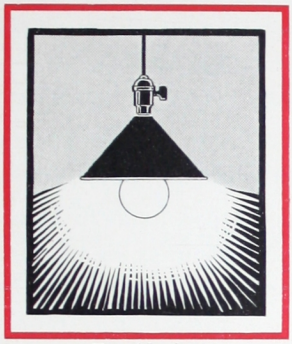
It requires only the simple observation and notation of specific facts as they exist and to which probably you have never given conscious attention before.

Copies of this "Rating Scale for an Industrial Lighting System" are available without cost upon request.

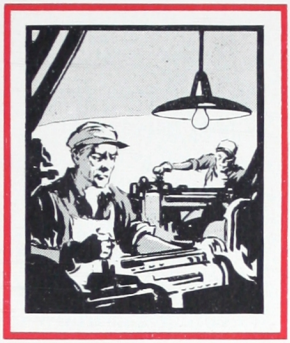
Here are the Evidences of Incorrect Factory Lighting



Bare Lamps



Tin Shades



Light Sources in Line of Vision

Spotty Light

Shadows on work

Dark Corners

Working in own light

To windows for seeing

Conditions such as those shown above are the most common defects in factory lighting. Some or all of them exist in seven out of ten industrial lighting systems—yet often persist unnoticed, year after year, until brought to the attention of management.

The Basic Elements of Correctly Designed Lighting Systems

A CORRECTLY designed system of industrial lighting is marked by the following elements and factors, which largely determine the character of the illumination provided. These factors, appearing on the Benjamin Simplified Rating Scale, are:

An Adequate Quantity of Light for the Work

The human eye has been developed under natural daylight where even on a cloudy day, out of doors, the intensity of illumination is hundreds of times greater than any created artificially. Obviously, then, there is little danger of providing too much light for workers in a system of artificial lighting. In fact the danger is in providing too little for employees' best seeing.

Many factories are well lighted by natural light, but when daylight fails the illumination provided by their lighting systems falls to but a small fraction of the intensity to which their employees are accustomed. Such a handicap to seeing seriously impairs productive efficiency.

How to Measure the Amount of Light

Intensity of illumination is expressed in foot-candles—an engineering measurement unit just as definite as B. T. U. or R. P. M. This foot-candle intensity of illumination on a working surface can be measured accurately by a simple instrument called the Foot-Candle Meter.

As shown in Table I (Pages 41 to 43 of this Guide), definite standards expressing the amount of light in terms of foot-candle intensities for various industries and types of operations have been determined as the result of study and evaluation of the best modern practice. These are definite accepted values against which you can compare the efficiency of your own lighting system.

Foot-Candle Meter

The Lighting Service Department of your Light and Power Company, the Lighting Specialists of your Electrical Contractor or Wholesaler, or a Benjamin Illuminating Engineer will have a foot-candle meter available to help you make these measurements.

If no foot-candle meter is available for determining the actual level of illumination in your plant, an approximation of the adequacy of your lighting can be obtained by computing the watts per square foot as explained in the Benjamin Simplified Rating Scale for an industrial lighting system.

For operations performed on dark colored material, a much higher degree of illumination will be required than for lighter work, as dark colors absorb a large portion of light reaching them. Thus to compensate for these absorption losses it is advisable to increase foot-candle recommendations by at least one-third for work on dark colors.

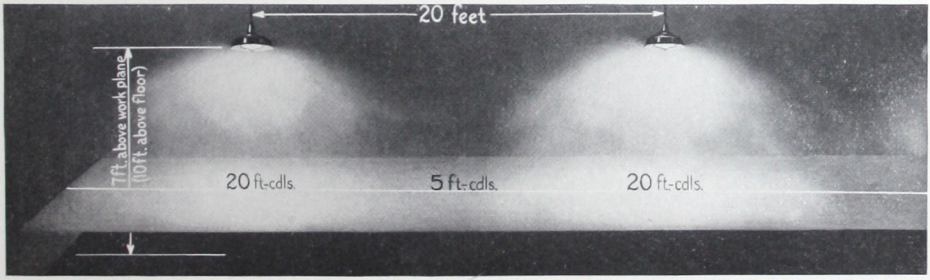
Many other operations requiring extreme accuracy will need intensities ranging from 50 to 100 foot-candles for best seeing. The most efficient and economical means of securing these intensities is to supplement the general lighting system at these operations with high intensity local lighting as provided by the Benjamin Intensifier which builds up the illumination over small areas to values adequate for fine work. Such methods have proved extremely valuable in exacting assembly work, die and tool making, engraving and similar operations.

Uniform Distribution of Light on the Working Surface

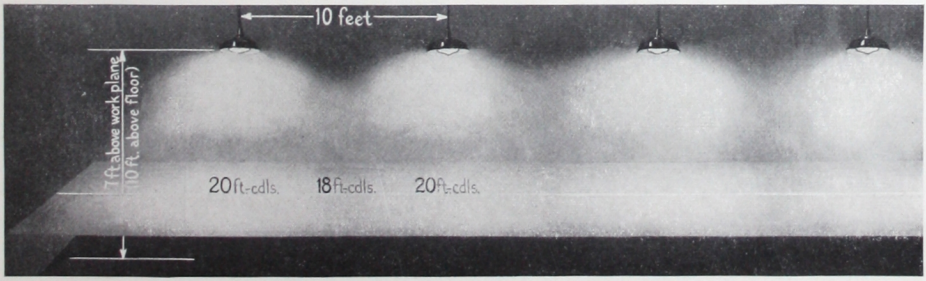
Adequate general illumination is only attained when there is an even or uniform distribution of light at the working plane. The size and number of light sources determine the quantity of light, but its uniformity of distribution is governed by the spacing and mounting height of the reflectors.

If lighting units are spaced too far apart, spotty and uneven illumination will result. Areas directly under the reflectors will be brightly lighted while areas falling between units will be appreciably dim and poorly lighted by comparison.

The accompanying diagrams illustrate graphically the effect on the distribution of light over the working surfaces when reflectors are spaced too far apart



Units too far apart—uneven illumination



Units correctly spaced—uniform illumination

Before good lighting—harsh shadows, glaring and uneven illumination.

After good lighting—uniform illumination, no glare, and shadows soft and luminous.

and when they are correctly located so as to give an overlapping of light.

In planning the specifications of a lighting system, follow the ratio of spacing between reflectors to the mounting height as discussed fully on page 37.

Quality of Light Should be Suitable

The quality of light, as distinguished from its quantity or foot-candle intensity, depends upon its color composition and upon the degree of diffusion it has undergone before reaching the eye.

For comfortable seeing the most suitable light is that which comes from a relatively large source of low unit brightness such as is provided by Benjamin porcelain enameled steel reflectors or by Benjamin Glassteel Diffusers which combine a diffusing glass globe with a porcelain enameled steel reflector.

Due to the predominance of red and yellow rays in the Mazda lamp it is often necessary to correct the color of artificial light. This is easily accomplished by using Benjamin Daylight glass globes in Glassteel Diffusers or by equipping reflectors with Daylight lamps or Benjamin Dust-Tight Covers with Daylight glass lenses.

Direct Glare Should be at a Minimum

Glare causes eyestrain and fatigue, reduces speed of vision and prevents discrimination of detail. Glare is either direct, caused by light sources in the direct line of vision, or indirect, caused by reflection from highly polished or light-colored surfaces.

In a correctly designed lighting system direct glare is eliminated or brought to an irreducible minimum by reflector equipment which shields the lamp from the worker's vision, by mounting the reflector units well above the working plane or by using Benjamin Glassteel Diffusers which enclose the lamp with a large diameter globe of diffusing glass, thereby reducing the brightness of the light source.

Control of Reflected Glare

Though reflected glare is as dangerous as direct glare, it is often difficult to escape it entirely, when polished surfaces must be worked on for long periods at a time.

As with direct glare, reflected glare can be minimized by increasing the size of the light sources, thereby decreasing the unit brightness, or by the use of diffusing globes as on the Glassteel Diffuser, or by shifting light sources so as to direct the reflections from polished surfaces away from the workers' eyes.

Shadows Soft and Luminous

A good lighting system is free from deep shadows and sharp contrasts of lighting intensity. Some shadows, however, are often an aid to seeing, for without this difference in lighting, objects would be invisible against a background of the same color and brightness.

Deep shadows may be sources of accident by preventing adequate seeing of protruding objects, etc. Aside from this, however, they cause eyestrain and slow-up seeing by bringing about frequent contraction and dilation of the pupil of the eye as worker's vision shifts from good light to poor, and vice versa.

Dark shadows are usually caused by the use of small, bright light sources or by light sources which are spaced too far apart. To soften shadows, in a correctly designed system, and to make them luminous, correct spacing of large light sources is important. Thus with units spaced correctly, the overlapping of light on the working surface softens shadows. As the light is coming from all directions, objects and backgrounds are more uniformly lighted.

Contrast of Lighted Objects and Backgrounds Should not be Extreme

Excessive contrast between a well lighted working surface and the dark background areas of wall and ceiling emphasizes the brightness of the light sources and causes eye-strain and fatigue as the eyes try to accustom themselves to the different conditions.

Without uniform distribution of light the shop looks gloomy and cheerless, with the inevitable effect upon workers' morale.

To eliminate noticeable contrasts, a lighting system should be designed to give a comparable intensity of light on side wall and ceiling backgrounds of the room. Even a fair portion of light on walls and ceiling will do much to make contrast less apparent.

Walls and Ceilings Should be Light and Clean

The reflecting efficiency of the walls and ceiling is an important factor in a good lighting system. Where the reflecting efficiency of walls and ceiling is high (that is, if walls and ceiling are clean and of light color), a greater proportion of light will be reflected from them and also there will be a minimum of contrast between them and the working surfaces.

On the other hand, if walls and ceiling are dirty or painted a dark color, they will absorb a greater part of the light reaching them, thus constituting a definite waste of light and reducing the efficiency of the system.

In planning specifications of a correct lighting system, condition of walls and ceiling are important and affect definitely other calculations. The relation of interior room conditions affecting specifications is fully explained in Table II, page 44 of this booklet.

Lamps Burning at Maximum Efficiency

In the lighting system it is important that all lamps be operated at their rated voltage. Any drop in voltage below that at which lamps are rated, or the use of lamps rated above the voltage of the current supply, only results in a decrease in illumination which is many times greater than any saving in current cost.

The light output of a lamp falls off three times as fast as the voltage. So that if a lamp is burned at 5 per cent undervoltage, there will be a 15 per cent loss in light output.

Burned-out and blackened lamps should be replaced immediately as they decrease the efficiency of the system. Blackened lamps in particular should be replaced as soon as found as their loss in illumination output is excessive. In general, lamps allowed to burn beyond their rated life reduce the efficiency of the system materially.

Regular and Frequent Cleaning of Lamps and Reflectors

Dirt on reflector and lamp surfaces absorbs light and decreases the efficiency of the lighting system to such an extent that nearly half the light being paid for may be wasted. A regular schedule of cleaning should be instituted in the plant so as to have maintenance work done periodically. Not only is there actual waste when dirt absorbs a large portion of light being paid for in current consumption, but the reduction in illumination on the working surfaces will lower the working efficiency of employees by impairing their ability to see clearly.

Wiring Adequate for Future and Present Needs

Continual advances in standards and practices in industry make it essential to design the original wiring installation with a margin for the future.

In an industrial plant, for example, a structure may be planned for warehouse use with relatively low lighting demands. Changed conditions make it desirable to use the building for manufacturing, with its attendant requirement of plenty of well diffused light. If the entire wiring system has been designed with sufficient capacity in the first place, the increase can be accomplished with a minimum expenditure of time and money.

At the time of installation the wattage capacity of the wiring system can be doubled at but a slight increase in cost. As compared to the cost of rewiring at a later time when an installation of higher wattage is to be put in, the saving of providing adequate wiring for future needs is considerable.

For present needs, a wiring system should be at least adequate to the point of avoiding voltage drop to lamps, as such a drop in voltage will reduce the illumination output efficiency of the lamp.

It is not sufficient that an installation is wired in accordance to the National Electrical Code only, for the Code is not an illumination standard but merely a standard of safety against fire hazards.

Installation Conforms to Franklin Red Seal Specifications

The Franklin Red Seal Specifications are a standard of adequate lighting prepared co-operatively by the electrical industry and provides a simplified method of determining outlet spacing, lamp size and mounting height for general lighting installations.

Get all the Advantages of Better Lighting with Benjamin Porcelain Enamel Steel Reflectors

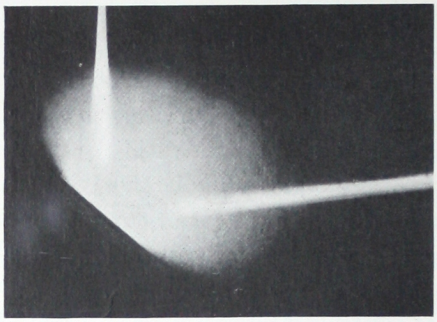


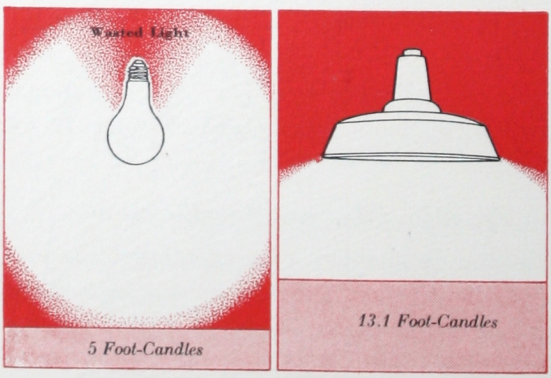
Photo-Analysis of Reflection from Porcelain Enameled Steel

THE modern Mazda lamp, with the scientifically designed Benjamin Porcelain Enameled Steel Reflector, provides an economical and highly effective means of securing adequate illumination for every department of your plant. Part of the light from the lamp, which would otherwise be wasted, is intercepted by the reflector and redirected to the working surface, increasing the intensity of illumination. At the same time the reflector shields the lamp and thus minimizes direct glare from the filament, preventing interference with the vision of your workers.

Light is soft and well diffused

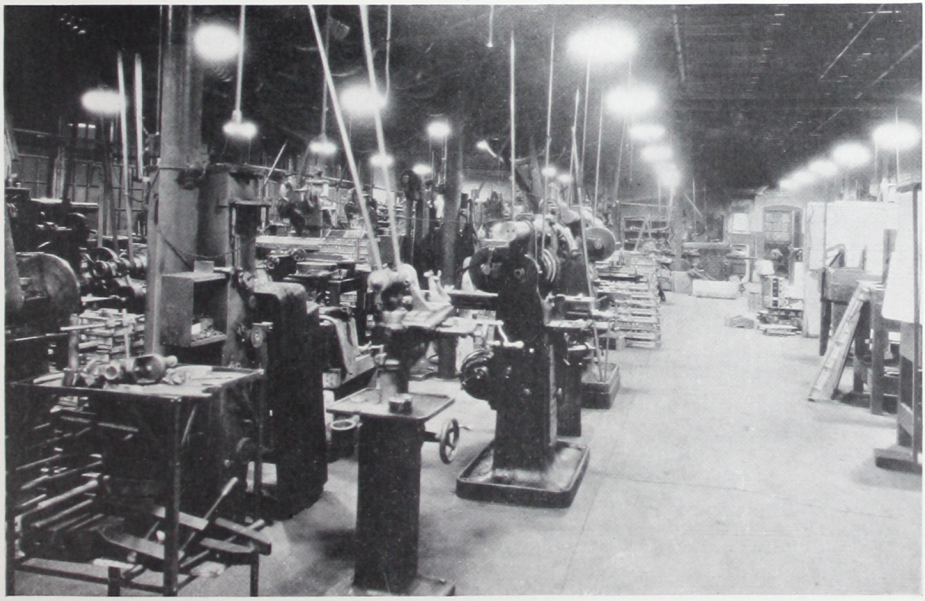
Of equal importance are the diffusing properties of the porcelain enamel reflecting surface, resulting in soft and well diffused illumination, which is pleasing to the eyes of your employes. Benjamin Porcelain Enameled Steel Reflectors are therefore especially adapted to the requirements of every industrial operation.

Moreover, the economical operation of your lighting system is assured by high initial efficiency, the ruggedness and permanency of the snow-white porcelain enamel reflecting surfaces of Benjamin Industrial Lighting Fixtures. Because of its glass-like composition, the Benjamin porcelain enamel reflecting surface does not tarnish nor discolor, and is kept at its original high reflecting efficiency throughout the life of the installation.



Only periodic cleaning with soap and water is required. But no matter how often these reflectors are cleaned, the reflecting surface will not be affected.

Before good lighting—harsh shadows, glaring and uneven illumination.



After good lighting—uniform illumination, no glare, and shadows soft and luminous.

How to Obtain a Productive Lighting System

TO secure an adequate system of lighting for a plant or any other location in which people work or play, the following four steps are usually followed:

FIRST

The amount and kind of illumination required is determined. In each department every operation is studied to determine the whole problem involved in providing adequate illumination. This does not only include the amount of light that may be required, but also the methods that have to be used to secure this illumination on the surface to be lighted.

SECOND

The special conditions the lighting system must serve are determined.

Here would be considered whether the lighting equipment is exposed to dampness or dust, whether gases or vapors are present, whether heavy vibration or shock must be guarded against, and other factors that influence the life and the effectiveness of the equipment used.

THIRD

The proper shape and type of reflector equipment is selected.

Benjamin equipment is designed to meet every type of lighting problem and serve the various types of conditions arising in the operations of a lighting system.

The various shapes and types of reflecting equipment have been scientifically designed by illuminating engineers to meet specific purposes, namely:

(1) General overhead lighting

(2) Lighting from the side

(3) Supplementary or locally intensified lighting

(4) Specialized applications.

With the key—that reflector equipment must be selected for its lighting purpose and to meet the conditions controlling its location—there need be no confusion or difficulty in determining which specific reflector equipment should be selected from the following pages. This Guide outlines only the types of equipment more generally used. A complete listing, including standard types of equipment and many special units, will be found in the Benjamin catalog, available upon request.

FOURTH

From various tables shown on pages 37-48, and from instructions for special equipment, supplied with the fixtures, layout, spacing and mounting are determined.

The Benjamin Symbol of Quality

THE Benjamin red diamond label of quality is your assurance of the greatest measure of efficiency, reliability and durability from your lighting equipment. It is a symbol of good service and your protection against inferior equipment—a label of safety in which you can place utmost confidence.

Be sure, when buying lighting equipment, that it bears the Benjamin Red Diamond of Certification. This label appears on every reflector. It provides a means that permits buying reflector equipment on a basis of assured results.

This Label Certifies:

1. That all lighting fixtures are designed in accordance with best illuminating engineering practice to direct to the working plane a maximum quantity and suitable quality of light.

2. That the porcelain enamel surface of Benjamin Certified Reflectors combines unusual durability with high reflecting value that is in excess of standard engineering specifications.

3. That fixtures are carefully constructed by the Benjamin Electric Manufacturing Company to give full length of service and to insure the reliable performance of the lighting system.

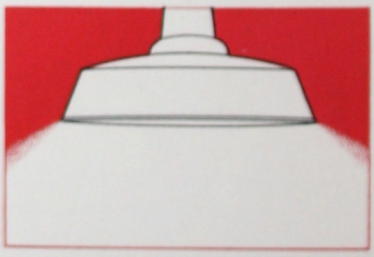
Benjamin RLM Dome Reflector

for good general overhead lighting

GOOD lighting is always first of all good general illumination over the whole factory interior. In most locations, this means good overhead lighting. The Benjamin R.L.M. Dome Reflector provides good general purpose overhead lighting and is applicable to the majority of conditions found in industrial interiors.

An accepted standard of general lighting, the Benjamin R.L.M. Dome Reflector is made to the specifications developed by lighting experts of Reflector and Lamp Manufacturers (R.L.M.) and is certified not to fall below these lighting standards by the Electrical Testing Laboratories of New York.

This reflector provides a maximum of light on working surfaces with a minimum of direct and reflected glare. It provides good illumination on both horizontal and vertical surfaces and minimizes shadows on the work.

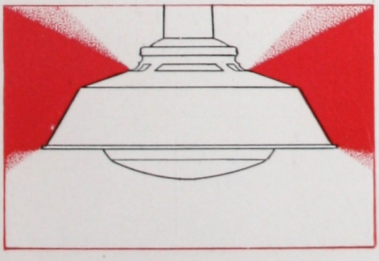


The shape of the R.L.M. Dome Reflector is scientifically designed to shield workers' eyes from the direct glare of the lamp filament.

Benjamin Glassteel Diffuser

for very best overhead general lighting

IN the Glassteel Diffuser is found the diffusion and high reflecting efficiency of porcelain enamel reflectors to which has been added the diffusive properties of a translucent glass globe. Shadows and sharp contrasts are almost wholly eliminated; approximately 11 per cent of the total light output is thrown upward on ceiling through apertures in the top of the reflector, relieving harsh background contrast and giving the room a bright, cheerful appearance. The diffusing glass globe allows the use of high intensities without glare. Light is well distributed on both horizontal and vertical surfaces. May be supplied with "Daylight" glass globe for operations where color correction is needed.



Widely used in tinshops and where the material worked on is shiny or glossy.

As the low surface brightness of the unit minimizes glaring reflection, Benjamin Glassteel Diffusers are especially recommended wherever work requires close and continued use of the eyes and standards of workmanship are exacting.

Benjamin Elliptical Angle Reflector

for lighting from the side

IN many industrial locations, unusually high ceilings or the presence of overhead traveling cranes make side lighting necessary. In still other locations side lighting units are used in conjunction with general overhead lighting in building up illumination over certain designated areas or for lighting underneath overhanging machinery.

When properly mounted and spaced, the Elliptical Angle Reflector gives uniform illumination over both horizontal and vertical surfaces. It distributes the light not only to the front but has a wide lateral distribution as well which builds up the illumination between units to provide uniform lighting of the working surfaces.

The shape of the reflector is such that the eye is shielded from direct glare of the lamp.

The Benjamin Elliptical Angle Reflector is adaptable to a wide range of industrial lighting requirements and is especially suitable for installation in foundries, textile mills and paper mills, and for lighting tire rolling and beading machines, paper-making machines and calendering rolls.

The Benjamin Intensifier

for supplementary high intensity lighting of small areas

INTENSIFIED local lighting is obtained by use of the Benjamin Intensifier where the light must be projected from the side or from a distance of several feet or at an angle to avoid casting shadows.

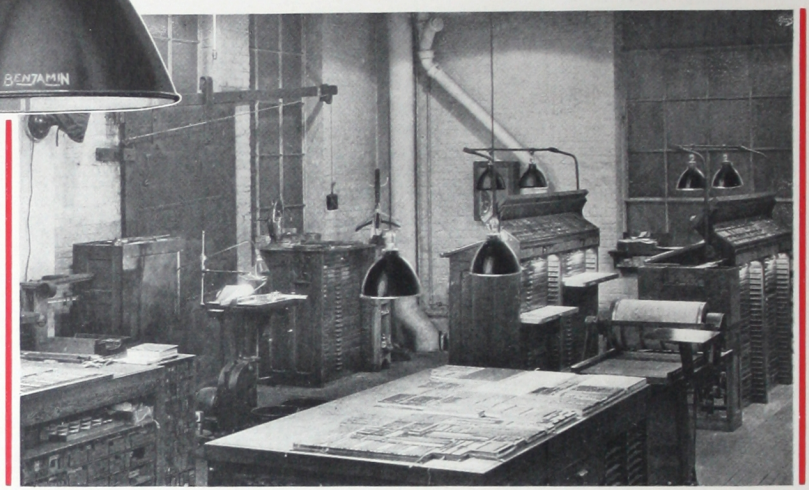
The Intensifier is a specially developed supplementary lighting unit for illuminating small areas to intensities ranging from 35 to 250 foot-candles. The narrow beam concentrates the light over a small area and permits the closest discrimination and the most accurate work.

The Intensifier offers a solution to the problem of lighting special industrial operations requiring a greater concentration of light than is provided by the general lighting system. The fixture is fully adjustable and may be mounted at the most suitable position in relation to the work. To avoid excessive contrast between the brightly lighted area of the Intensifier and surroundings, it is always essential to use the Intensifier in conjunction with a good general system of lighting of fairly high intensity.

The Intensifier has proven suitable for illuminating fine assembly work, dies, engraving, shoe stitching, and other similar operations where an exacting character of work is being performed.

Benjamin Deep Bowl Reflector

for local lighting of machines and benches



BENJAMIN Deep Bowl Reflectors are particularly designed for the local lighting of machines or workbenches where a fairly high intensity is needed on horizontal surfaces. Installed directly over the area they provide sufficient illumination for fairly close work.

The Deep Bowl Reflector should be used only in conjunction with a good general system of lighting.

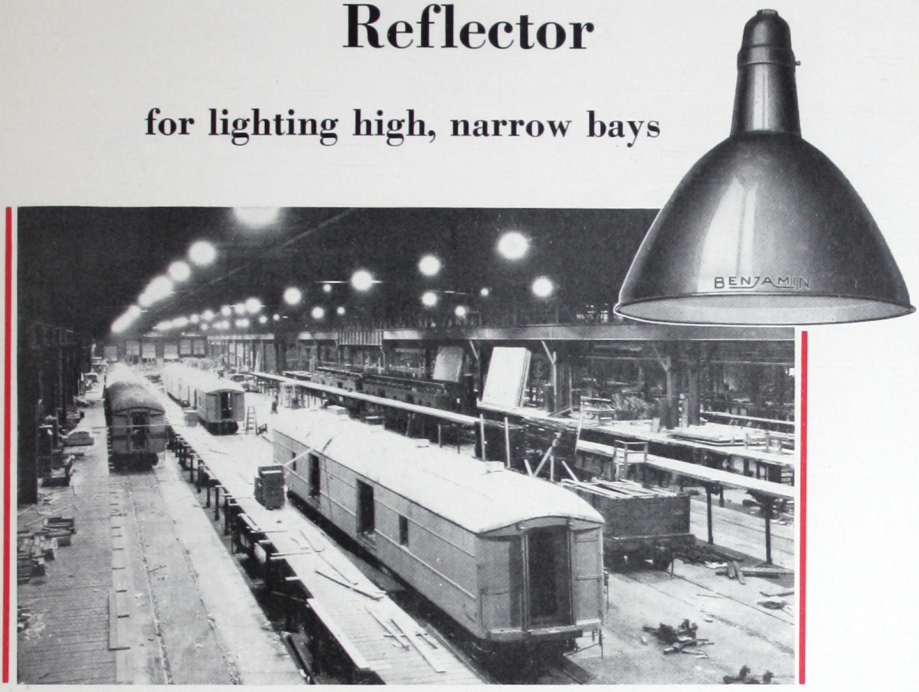
The design of the reflector shields the lamp and eliminates direct glare.

The Benjamin Symmetrical Angle Reflector

The Benjamin Symmetrical Angle Reflector is especially suited for use in locations where local lighting from the side is needed. The special design of the reflector gives good illumination on vertical surfaces. This Benjamin reflector is widely used to light storage shelves, filing cases, overhanging machinery, and similar locations.

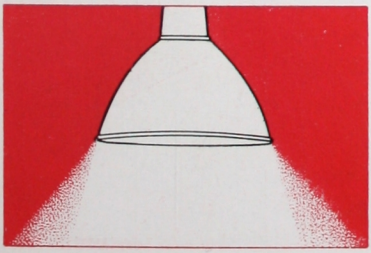
Benjamin Concentrating Type Reflector

for lighting high, narrow bays



THE Benjamin Concentrating Unit is recommended for lighting high, narrow rooms or bays where the mounting height of the reflector from the floor is equal to or greater than the width of the room to be lighted. It also has a wide application for the lighting of outdoor locations.

From mounting heights of 15 to 80 feet, this unit concentrates a high intensity of light on the working areas directly below the unit, with a minimum wastage of light on the upper walls of the room. It is recommended for the lighting of comparatively narrow rooms where not more than three rows of units are required. The special aluminum oxide reflecting surface and the shape of this reflector are particularly effective in giving control of the light on working surfaces from high mountings.

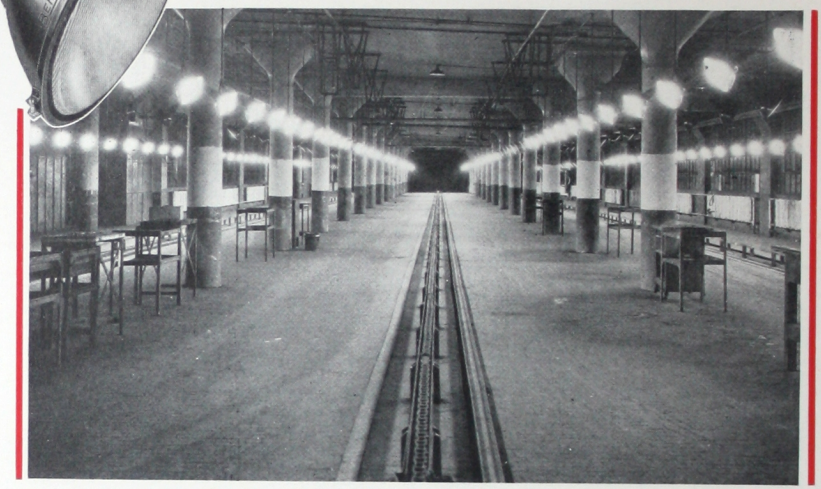


The unit is light in weight and is made in a separable hood construction. It is desirable to use the Dust-Tight Cover with this unit for greater economy in properly maintaining the lighting efficiency.

Also available with a universal mounting bracket for use as an industrial floodlight.

Benjamin Gas and Vapor Proof Projectolite

for lighting at a grazing angle



A SPECIALLY designed gas and vapor-proof lighting unit for use wherever a surface must be illuminated from an acute or grazing angle. The powerful beam of the unit is flattened and broadened by a special lens which directs a greater part of the light to a point farthest from the light source and a correspondingly lesser portion to points nearer the reflector.

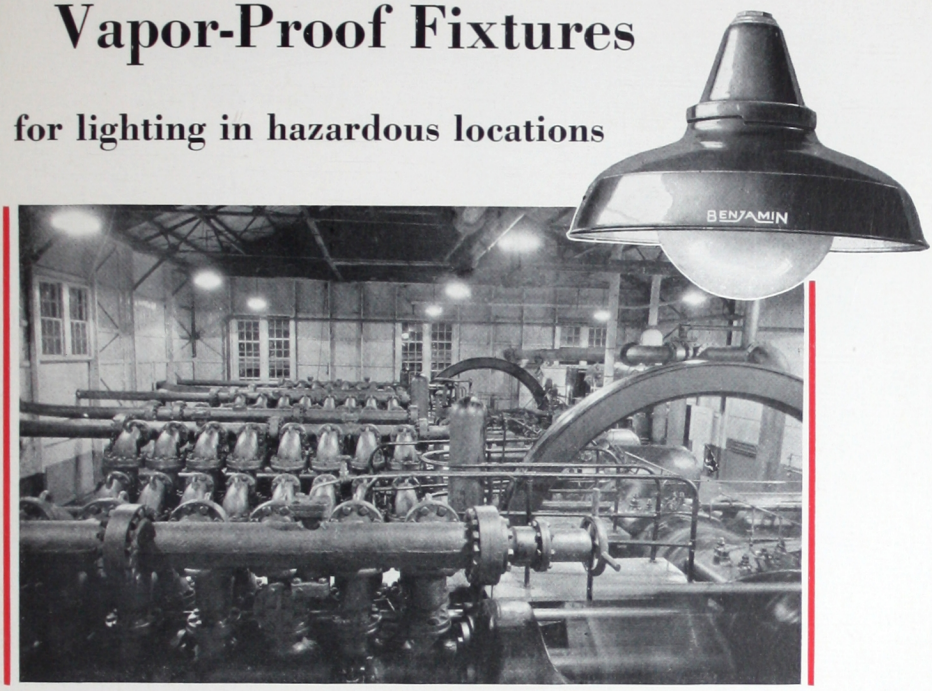
The result is an illumination of approximately uniform intensity over the entire surface. The Benjamin Gas and Vapor-Proof Projectolite is used extensively in automobile body plants, lacquer and paint spray booths, furniture finishing departments and other locations where this type of lighting must be accompanied by gas and vapor-proof protection.

The Benjamin Gas and Vapor-Proof Projectolite is listed as "Vapor Proof" by the Underwriters' Laboratories and is suitable for installation in Class I hazardous locations as defined in the National Electrical Code.

The unit is provided with an adjustable ball joint hanger which permits positioning reflector at any point through a wide arc.

Benjamin "Series 1500" Gas and Vapor-Proof Fixtures

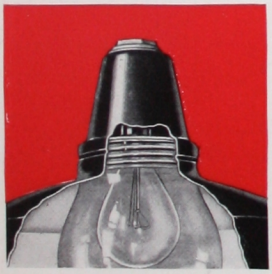
for lighting in hazardous locations



WHEREVER the manufacturing process or the materials handled produce an inflammable or explosive mixture in the atmosphere, the presence of unprotected lamps is a hazard.

Because of this hazard of fire or explosion, the National Electrical Code requires that lamps installed in hazardous locations shall be enclosed in vapor-tight globes or other approved enclosures.

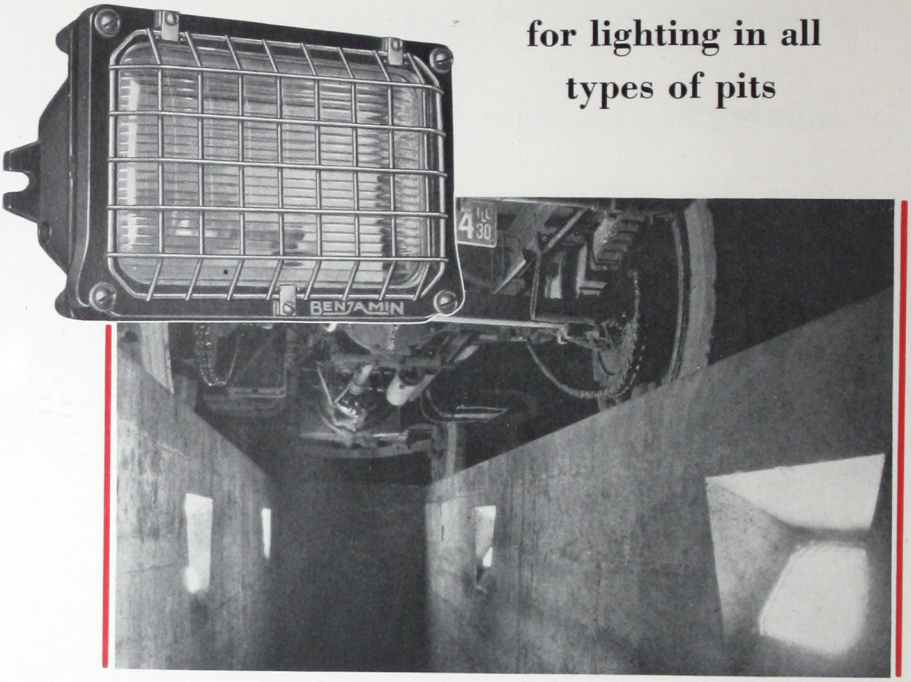
Benjamin "1500 Series" Gas and Vapor-Proof fixtures are listed by the Underwriters' Laboratories as "Vapor Proof" and are suitable for installation in hazardous locations as defined by the National Electrical Code. In these fixtures the lamp is enclosed by a clear glass globe. Benjamin "1500 Series" Gas and Vapor-Proof fixtures are designed to conform to the highest standards of lighting efficiency in addition to providing adequate protection.



This fixture is especially recommended for locations such as: Powder Mills, Oil Refineries, Paint and Varnish Works, Lacquer Spraying Departments and Natural Gas Plants.

Benjamin Pit Lighting Fixture

for lighting in all types of pits

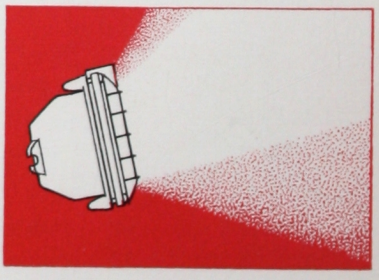


THE Benjamin Pit Lighting Fixture, with Refracting glass cover, offers a most satisfactory means of obtaining adequate illumination in all types of service pits.

The efficient trough-shaped reflector assures maximum light output, while the refractor cover of heat-resisting glass concentrates the major portion of the light on the undercarriage of the vehicle over the pit. The Benjamin Pit Lighting Fixture is entirely water-tight and gas-proof. All joints are sealed against gas, vapors, water and moisture. The body of the fixture and the cover frame are heavy castings to insure long service under severest conditions.

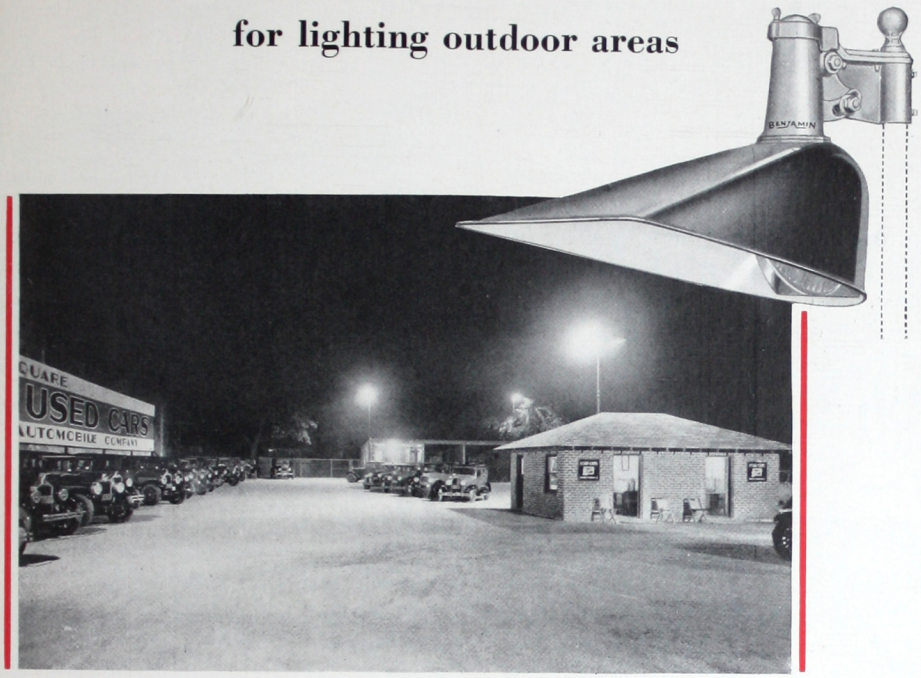
The Pit Lighting Fixture is suitable for built-in or surface installation in automobile service and greasing pits, railway and traction line repair pits, wash racks, hydraulic lifts and similar locations.

This fixture is widely used in lighting tunnels, subways and viaducts. May also be had with plain heat-resisting glass cover..



Benjamin Duo-Service Floodlight

for lighting outdoor areas

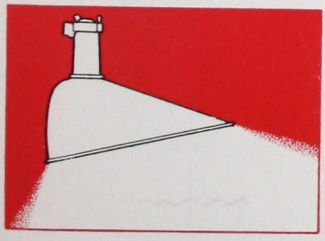


COMBINING in one unit a floodlighting projector and diffusing reflector, the Benjamin Duo-Service Floodlight is used extensively where a ground area is to be lighted and a building or object, in or beyond the area, is to be floodlighted at the same time to a higher intensity.

A special highly polished metal projector utilizing a portion of the light from the lamp floodlights the object or area to be emphasized. The porcelain enameled steel diffusing reflector provides general illumination of the area surrounding the unit.

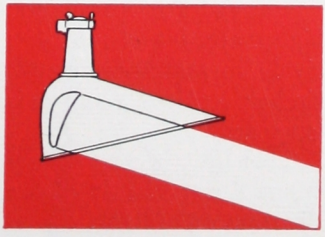
This unit is widely used industrially for lighting yard areas around the plant, for coal and material handling yards and outdoor storage areas.

The fixture is rugged and entirely weatherproof, with adjustments for positioning the reflector and focusing of floodlighting beam.



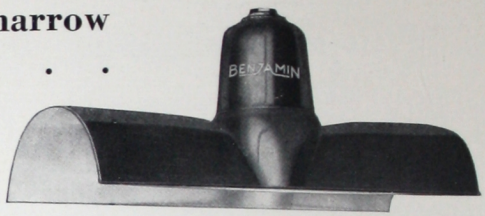
At left, is shown an approximation of the light distribution from the diffusing reflector.

At right, is shown an approximation of the distribution of the concentrated floodlight beam incorporated in the same unit.



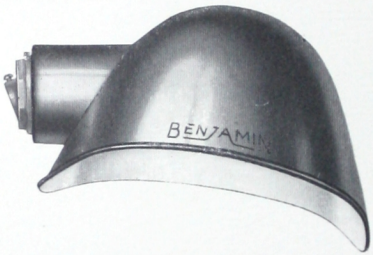
The Benjamin Parabolite

for lighting long, narrow areas . . . . . .



PORTIONS of the light from this unit are projected in long, narrow beams front and back by the elongated design of the reflecting surface. The Benjamin Parabolite is especially suited to the lighting of long, narrow areas, such as platforms, runways and alleys, where the peculiar character of the light distribution conforms to the shape of the areas.

The Benjamin Sign Reflector



for lighting wall and display signs . . .

ESPECIALLY designed to illuminate all types of posters, wall signs and display boards uniformly from top to bottom. Eliminates shadows and "scallops" from bottom of wall or board and reduces spillage of light over top.

The Benjamin Sign Reflector is widely used for floodlighting the walls of buildings where height is not excessive. The reflector is small and inconspicuous and attaches directly to a straight conduit, eliminating bends and ells. Wide lateral spread of light from the reflector maintains uniform illumination across the surface to be lighted by building up intensity between units.

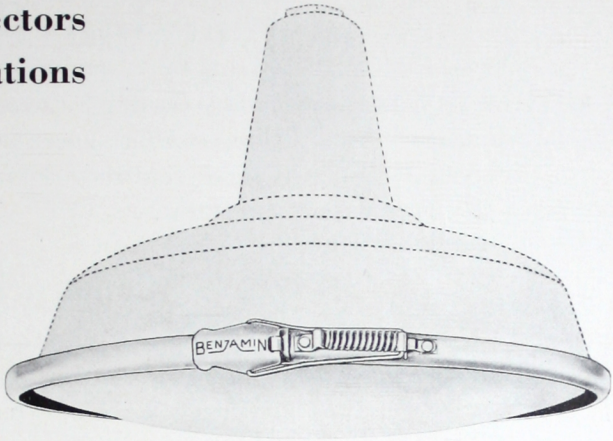
The Benjamin Fluted Bowl

THE Benjamin Fluted Bowl Reflector has been designed for installation in locations where fairly high mounting of reflectors is necessary. Used extensively in foundries, erecting shops, roundhouses and similar locations where an intensive distribution of light is needed.

This unit is also widely used in outdoor locations where the special fluted construction provides efficient distribution of light.

Benjamin Dust-Tight Cover

for keeping reflectors clean in dusty locations



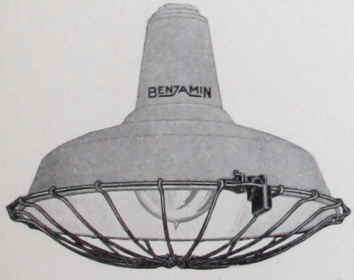
THE efficiency of any lighting system, especially in those locations where excessive dust and dirt is present, is dependent upon thorough and frequent cleaning of the lighting equipment.

The Benjamin Dust-Tight Glass Cover readily attaches to Benjamin Reflector equipment and affords an economical method of keeping the reflectors and lamps clean. With the Dust-Tight Cover, it is necessary only to wipe off the smooth outer surface of the glass disc as compared with cleaning the lamp and reflecting surfaces of open reflector equipment.

Where combustible fibres or materials producing combustible flyings are handled or manufactured, the New Benjamin Dust-Tight Cover attached to the bottom of Benjamin reflectors will keep particles from collecting on hot lamps, as required by the National Electrical Code. These hazardous locations include textile mills, cotton gins, woodworking plants and similar establishments.

Benjamin Wire Guards

for protecting lamps against breakage



BENJAMIN Wire Guards attached to lighting fixtures give adequate protection against accidental breakage and damage to lamps and reflector surfaces in locations where unusual service conditions are encountered.

Guards are heavy tinned wire and will withstand severe service. Benjamin Wire Guards are available for most Benjamin reflectors. They are readily attachable to reflector rim, becoming an integral part of the unit.

Benjamin Reflector Equipment Construction Types

A PRIMARY consideration in selecting reflector equipment is the peculiar conditions of service and maintenance under which it is to be used. Each of the following Benjamin reflector construction types has been especially designed to meet a specific requirement.

"Type 79" Construction

A NEW and unique two-piece, quick detachable construction by which lamp and reflector can be taken down as one complete unit.

A three point bayonet coupling attaches or detaches reflector unit to the hood by a simple quarter turn of the reflector, making cleaning faster and more economical. With a few extra reflectors on hand the maintenance crew can change an entire bay at a time—simply replacing dirty units with clean units washed previously on the floor.

Electrical and mechanical connection between the hood and reflector is made simultaneously with the engagement of the bayonet lock. The terminal base in the hood is backed by a spiral compression spring which maintains the contacts of the hood and reflector in positive electrical engagement.

Terminal base and lamp holder contacts are circular in form, with broad, flat surfaces which are self-cleaned by the turn of the reflector as it is engaged in the hood. Hoods and reflectors are completely interchangeable. Furnished in sizes up to 1000 watts. Made in RLM Dome, Shallow Bowl and Glassteel Diffuser.

One-Piece Socket-reflector Construction

THOROUGHLY weatherproof, one-piece equipment for either indoor or outdoor installation where interchangeability of reflectors or easy removal for cleaning is not a consideration. Strong and durable construction with heavy fitting and easily wired socket. Supplied in sizes up to 1000 watts. Made in RLM Dome, Deep Bowl, Shallow Bowl, Flat Cone, Elliptical Angle, Symmetrical Angle and Parabolite Shapes.

Type RR Construction

UNUSUALLY rugged two-piece, threaded hood design for severe service conditions in locations such as steel mills, railroad repair shops, roundhouses, foundries and the like where fixtures are subjected to excessive mechanical strain and corrosion of smoke and vapor. Easy to install and clean. A common thread makes reflectors and hoods completely interchangeable.

Reflectors have copper thread to prevent corroding or "freezing" of the neck to the hood. Hoods are either of heavy cast iron or porcelain enameled steel. Furnished in sizes up to 1000 watts. Made in the RLM Dome, Deep Bowl, Shallow Bowl, Fluted Bowl and Symmetrical Angle Shapes.

Sturdox Construction

UNUSUALLY strong and durable two-piece, threaded hood equipment for installation in the average industrial location either indoors or out. Will stand up indefinitely under average service conditions; is easily installed and cleaned. A thread common to all hoods and reflectors makes reflectors interchangeable. Hoods are cast iron or enameled steel. Supplied in sizes up to 1000 watts.

Made in the RLM Dome, Shallow Bowl, Deep Bowl and Symmetrical Angle Shapes.

Shade-Holder Construction

FOR locations where from economy it is necessary to utilize existing outlets or sockets. Made with four styles of holders to accommodate most of the sockets now in general use. When attached to sockets for which designed lamp filament will be in the proper position for efficient illumination. Made in sizes for lamps up to 200 watts.

Made in RLM Dome, Deep Bowl, Shallow Bowl and Symmetrical Angle Shapes.

Benjamin Sockets and Fittings That Increase Serviceability

Shock-Absorbing Socket

LAMP replacement plays an important part in maintenance of a lighting system. While lamps are rugged and durable, actual tests have proved that lamp life is shortened by mechanical shocks and vibration.

Vibration is never entirely eliminated, but by using Benjamin Shock-Absorbing Sockets the lamp is cushioned against vibration so that full rated life is obtained from the lamp.

The Benjamin Shock-Absorbing Socket can be specified in place of the regular socket on most Benjamin reflectors. A special bronze spring between the fitting and the body of the socket floats the socket body and absorbs the mechanical shocks and jars instead of transmitting them to the lamp filament.

Pull-Chain Socket

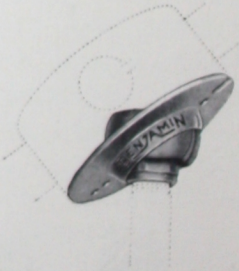
Where individual control of the lighting unit is desirable, the Benjamin Pull-Chain Socket should be substituted for the regular socket equipment in the reflector. The pull chain hangs straight down inside the reflector and does not interfere with the fixture in any way. This socket, in proper reflector equipment, can be used outdoors.

Self-Locking Socket

To prevent theft or unauthorized removal of lamps from reflectors the Benjamin Self-Locking Socket is a necessary accessory in the lighting system. The socket locks automatically when the lamp is screwed in and a special key which can be available only to persons with proper authority must be inserted in the socket and the mechanism unlocked to remove the lamp from the socket.

Benjamin Self-Locking Sockets may be had in place of regular socket in most reflectors. Combination of Self-Locking and Shock-Absorbing Sockets can be supplied.

Ball Fixture Aligner



A compact and sturdy outlet box cover type of ball aligner which permits fixtures to hang plumb even when outlet box is mounted at 45° angle from horizontal.

The Benjamin Ball Fixture Aligner is suitable for installation in every industrial location. This aligner attaches directly to standard outlet boxes by means of two screws.

A Simplified Method of Determining Spacing and Mounting Height

for a General Lighting Installation

THE following tables provide a simplified method of determining outlet spacing, lamp size, and mounting height for general lighting installations in industrial interiors.

The four steps outlined below present a standard method through which tedious calculations are avoided; technical considerations have for the greater part been reduced to the form of tables which operate automatically with results that are sufficiently accurate for all practical purposes.

This method has been tested in actual industrial lighting installation work over a long period of time and has been found to be of the utmost practical service. Should, however, the conditions of the location be so unusual as to make the use of this method inadvisable, Benjamin Illuminating Engineers will gladly assist in planning a lighting system that will be entirely adequate to meet the conditions of the location to be lighted.

First—*Locate foot-candle intensity required for the type of work carried on in the location to be lighted—TABLE I*, Pages 41-43.

NOTE: It is to be observed that a range of foot-candle intensities for each type of work is recommended. It is suggested that where first-class lighting is wanted, the upper or higher limit be chosen. Where it is desired that the installation meet minimum requirements, the lower intensity is acceptable. Any increase in intensities above the recommendations shown in *TABLE I* will materially increase the value of the installation.

Second—*Decide conditions of the interior of the location to be lighted—TABLE II*, Page 44.

Third—*Determine the most suitable reflector for the type of work carried on*—from illustrations and comments given on Pages 22-23.

Fourth—*Determine spacing of reflectors and size of lamps—TABLE III*, Pages 45-46.

a. *Decide maximum mounting height possible with ceiling available.*

In industrial buildings with flat, unobstructed ceilings and ceiling heights of 10 to 16 feet, it is usually necessary to have underside of reflector approximately 2 feet below ceiling. Where pulleys, shafting, pipes, etc., are present, it is essential to come below these obstructions. For high ceilings with roof trusses, fixtures are usually mounted with underside slightly below or flush with bottom chord of truss.

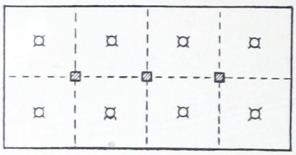
b. *Locate conditions of interior (as determined in TABLE II) in the space immediately to the right of the mounting height decided upon.*

c. *Then follow this line across horizontally to the right* until the desired foot-candle intensity as determined in *TABLE I* is located. Directly above this point, at the top of the column, will be found the required lamp and reflector size. The approximate spacing of reflectors is shown in the column at the left of the mounting height.

Typical Plant Lighting Layouts

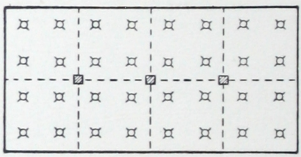
For Overhead Lighting Systems

WHERE interiors are divided by columns or ceiling beams into bays, it is usually desirable because of appearance and the possible future placing of partitions to locate the outlets symmetrically with respect to structural sections. The typical layouts and notes which follow are in accordance with general practice and suggest various arrangements of units with respect to bays.



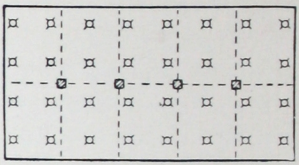
LAYOUT "A"

One Unit Per Bay—A very common practice, but satisfactory only where bay size is no greater than the maximum permissible spacing—an unusual condition.



LAYOUT "C"

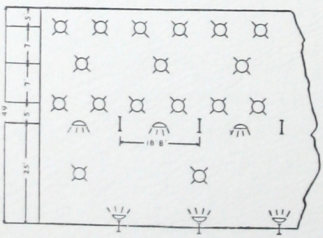
Four Units Per Bay—This is the most common system for the square bay of usual dimensions.



LAYOUT "B"

Four-Two System — This is equivalent to three units per bay and is an alternative to four per bay where permissible spacing allows.

For Combination Overhead and Side Lighting Systems



Overhead Units

Elliptical Angles

LAYOUT "D"

The diagram above shows the floor layout of the lighting system and type of reflectors used as indicated by the symbols.

In many locations the construction of the building and unavoidable overhead obstructions are such that direct lighting from overhead is impractical. A number of obstructions directly above the work and overhead cranes may cause such shadows that the efficiency of the overhead system would be greatly impaired.

The diagram at left is shown as the solution of such a situation—an installation of Benjamin Elliptical Angle reflectors supplemented by a single row of overhead units mounted above the traveling crane.

Provision for Adequate Wiring Is Important

THE following specification defines the minimum limits of wiring installations for lighting and other applications of electricity commonly supplied from so-called "lighting" circuits that will provide adequate carrying capacity and reasonably low voltage drop. This specification applies only to installations for connection to 110 volt or 110-220 volt distribution systems and does not apply to wiring for the supply of energy to power equipment.

This specification is based upon 15 ampere fusing of branch circuits. If local regulations limit the load on branch circuits to less than 15 amperes, the wattage and area limits herein specified should be proportionately reduced.

As the requirements given herein are minimum, it is recommended that the installation be increased and elaborated upon in proportion to the design, scale and appointment of the structure.

Area and Loading of Lighting Circuits

In localities where 15 ampere (1650 watts at 110 volts) fusing of branch circuits is permitted, the loading per circuit of the initial installation in a commercial and industrial interior should be not over 1000 watts, and any one branch circuit should supply the lighting for a work space or rentable area not greater than 400 square feet or a bay approximately 20 feet by 20 feet; nor should one branch circuit supply the lighting for more than 800 square feet of hall or passageway or other non-rentable or non-productive area.

Where local electrical ordinances limit the permissible load per circuit to less than 1650 watts, the initial loading per circuit and the area per circuit should be proportionately reduced.

Wire Sizes for Lighting Circuits and Feeders

Branch Circuits

Not less than No. 12 B. & S. gauge wire should be used, either for runs from panel board to first outlet, or for runs between outlets. For runs of 50 to 100 feet from panel board to first outlet, not less than No. 10 B. & S. gauge wire should be used, and not less than No. 12 between outlets.

Runs exceeding 100 feet from the panel board to the first outlet should be avoided wherever possible, by the addition or relocation of panel boards. Where such runs cannot be avoided, the initial lamp load should be limited to 600 watts for each circuit, and wire not smaller than No. 10 B. & S. gauge should be used between the panel board and first outlet.

Convenience outlets should not be placed on any circuit supplying ceiling lighting outlets. Walls and baseboard convenience outlets generally should be of the duplex type. Not more than six duplex outlets should be placed on one circuit, using not less than No. 12 B. & S. gauge wire where the run from panel

board to first outlet is less than 100 feet, and not less than No. 10 B. & S. gauge wire where the run exceeds 100 feet.

Panel Boards

Panel boards should contain a minimum of one spare circuit position for each five active circuits or fraction thereof.

In general, there should be at least one panel board on each floor of the building. Wherever possible, panel boards should be located that branch circuit runs exceeding 100 feet to the first outlet can be avoided.

Feeders

In localities where 15 ampere (1650 watts at 110 volts) fusing of branch circuits is permitted, the feeders should be of such size that the voltage drop from the source of supply to the panel board will not exceed 1½ per cent with a load of 10 amperes at 110 volts on every branch circuit provided for, including spares.

Where local electrical ordinances limit the permissible load per circuit to less than 1650 watts, the initial loading per circuit for voltage drop calculations should be proportionately reduced.

Conduits for feeder wires should be of sufficient size to permit replacing the original feeder with a feeder two standard B. & S. gauge sizes greater in capacity.

The recommendations on this page refer to adequacy, including the elimination of excessive voltage drop, and are in addition to the usual minimum national and local regulations which, of course, must be complied with.

Watts Per Square Foot As One Measure of a Lighting System

There is a relationship between the amount of current in watts used by a lighting system and the amount of illumination secured. In general, the higher the wattage per square foot of area, other conditions being the same, the higher the foot-candle intensity obtained.

While it is quite common to compare lighting systems on the basis of watts per square foot, the amount of energy supplied does not indicate the amount of effective light reaching the working surfaces. Two installations of the same wattage may vary considerably in foot-candle intensity obtained due to differences in room conditions, mounting height of reflectors, efficiency of the lighting equipment and maintenance provided. This is clearly shown by the watts per square foot values included in Table III, pages 45 and 46, provided as a further means for forming a basis of measurement of a lighting system. To arrive at the watts per square foot of a room simply divide the square foot area of the room by the sum of watts supplied at all lighting outlets.

While it is not recommended to lay out a lighting system on the basis of watts per square foot, wattage may prove a convenient value for preliminary estimation. Best results from a lighting system will result when it is designed in accordance to Tables I, II, and III, as outlined in the specifications on page 37.

TABLE I — Recommended Foot-Candle Intensities for Industrial Interiors

THE following recommended foot-candles for industries and operations comply fully with all State Codes and in general are higher. State Codes are based on a minimum of illumination necessary for the preservation of vision and the avoidance of accidents; whereas these recommendations consider, in addition, the advantages of improved operating efficiency.

The values given in the following pages are for good productive lighting. Almost without exception, however, where higher intensities are used increases in operating efficiency will result.

NOTE: The intensities given on the following pages are based on work being done on light colored materials. Where dark materials are used, it is recommended to increase values by at least one-third.

	Minimum	Good Practice
AISLES, STAIRWAYS, PASSAGEWAYS	2 to	3
ASSEMBLING		
Rough	5 to	8
Medium	8 to	12
Fine	12 to	20
Extra Fine	25 to	100
AUTOMOBILE MANUFACTURING		
Automatic Screw Machines	10 to	15
Assembly Line	10 to	15
Frame Assembly	8 to	12
Tool Making	12 to	20
Body Manufacturing		
Assembly	10 to	15
*Finishing and Inspecting	25 to	100
BAKERIES	8 to	12
BOOK BINDING		
Folding, Assembling, Pasting	5 to	8
Cutting, Punching, Stitching	8 to	12
Embossing	10 to	15
CANDY MAKING	8 to	12
CANNING AND PRESERVING	8 to	12
CHEMICAL WORKS		
Hand Furnaces, Boiling Tanks, Stationary Driers, Stationary or Gravity Crystallizing	3 to	5
Mechanical Furnaces, Generators and Stills, Mechanical Driers, Evaporators, Filtration, Mechanical Crystallizing, Bleaching	4 to	6
Tanks for Cooking, Extractors, Percolators, Nitrators, Electrolytic Cells	6 to	10
CLAY PRODUCTS AND CEMENTS		
Grinding, Filter Presses, Kiln Rooms	3 to	5
Molding Pressing, Cleaning and Trimming	5 to	8
Enameling	6 to	10
*Coloring and Glazing	10 to	15
CLOTH PRODUCTS		
Cutting, Inspecting, Sewing		
Light Goods	10 to	15
Dark Goods	25 to	100
Pressing, Cloth Treating		
Light Goods	8 to	12
Dark Goods	12 to	20
COAL BREAKING AND WASHING, SCREENING	3 to	5
CONSTRUCTION		
Indoor General	3 to	5
DAIRY PRODUCTS		
Separators, Butter and Cheese Working	8 to	12
ELECTRIC MANUFACTURING		
*Storage Battery, Molding of Grids, Charging Room	6 to	10
Coil and Armature Winding, Mica Working, Insulating Processes	12 to	20
ELEVATOR		
Freight and Passenger	5 to	8
ENGRAVING	25 to	100
FORGE SHOPS AND WELDING	6 to	10
FOUNDRIES		
Charging Floor, Tumbling, Cleaning, Pouring and Shaking Out	5 to	8
Rough Molding and Core Making	6 to	10
Fine Molding and Core Making	10 to	15
GARAGE—AUTOMOBILES		
Storage		
Dead	2 to	8
Live	5 to	8
*Repair Department, Washing	10 to	15
GLASS WORKS		
Mix and Furnace Rooms, Pressing and Lehr Glass Blowing Machines	6 to	10
Grinding, Cutting Glass to Size, Silvering	8 to	12
Fine Grinding, Etching and Decorating	10 to	15
Glass Cutting (Cut Glass)	15 to	50
*Fine Polishing and Inspecting	15 to	50

NOTE: * Indicates operations or processes in which other factors, such as the direction of light, etc., are important considerations. Our engineers will gladly give their specific recommendations for such problems.

Recommended Foot-Candles—*Continued*	Minimum	Good Practice
GLOVE MANUFACTURING		
Light Goods		
Cutting, Pressing, Knitting	8 to	12
Sorting, Stitching, Trimming and Inspecting	10 to	15
Dark Goods		
Cutting, Pressing, Knitting	10 to	15
Sorting, Stitching, Trimming and Inspecting	25 to	100
HAT MANUFACTURING		
Dyeing, Stiffening, Braiding, Cleaning and Refining		
Light	6 to	10
Dark	10 to	15
Forming, Sizing, Pouncing, Flanging, Finishing, Ironing		
Light	8 to	12
Dark	10 to	15
Sewing		
Light	10 to	15
Dark	25 to	100
ICE MAKING		
Engine and Compressor Room	6 to	10
INSPECTING		
Rough	6 to	10
Medium	10 to	15
*Fine	15 to	25
*Extra Fine	25 to	100
*Glossy or Polished Surfaces	Glint Lighting	
JEWELRY AND WATCH MAKING	25 to	100
LAUNDRIES AND DRY CLEANING	8 to	12
LEATHER MANUFACTURING		
Vats	3 to	5
Cleaning, Tanning, Stretching	4 to	6
Cutting, Fleshing and Stuffing	6 to	10
Finishing and Scarfing	10 to	15
LEATHER WORKING		
*Pressing, Winding and Glazing		
Light	8 to	12
Dark	10 to	15
Grading, Matching, Cutting, Scarfing, Sewing		
Light	10 to	15
Dark	25 to	100
LOCKER ROOMS	4 to	6
MACHINE SHOPS		
*Rough Bench and Machine Work	6 to	10
*Medium Bench and Machine Work, Ordinary Automatic Machines, Rough Grinding, Medium Buffing, Polishing	10 to	15
*Fine Bench and Machine Work, Fine Automatic Machines, Medium Grinding, Fine Buffing and Polishing	12 to	20
Extra Fine Bench and Machine Work, Grinding (Fine Work)	25 to	100
MEAT PACKING		
Slaughtering	5 to	8
Cleaning, Cutting, Cooking, Grinding, Canning, Packing	8 to	12
MILLING—GRAIN FOODS		
Cleaning, Grinding and Rolling	5 to	8
Baking or Roasting	8 to	12
Flour Grading	15 to	25
OFFICES		
Private and General		
Close Work	10 to	15
No Close Work	8 to	10
Drafting Room	15 to	25
PACKING		
Crating	4 to	6
Boxing	6 to	10
PAINT MANUFACTURING	6 to	10
PAINT SHOPS		
Dipping, Spraying, Firing	5 to	8
Rubbing, Ordinary Hand Painting and Finishing	8 to	12
Fine Hand Painting and Finishing	10 to	15
*Extra Fine Hand Painting and Finishing (Automobile Bodies, Piano Cases, etc.)	25 to	100
PAPER BOX MANUFACTURING		
Light	6 to	10
Dark	8 to	12
Storage of Stock	3 to	5
PAPER MANUFACTURING		
Beaters, Machine, Grinding	4 to	6
Calendering	6 to	10
Finishing, Cutting, Trimming	8 to	12
PLATING	5 to	8
POLISHING AND BURNISHING	8 to	12

NOTE: * Indicates operations or processes in which other factors, such as the direction of light, etc., are important considerations. Our engineers will gladly give their specific recommendations for such problems.

Recommended Foot-Candles—*Continued*	Minimum	Good Practice
Power Plants		
Engine Rooms, Boilers, Coal and Ash Handling, Storage Battery Rooms	3 to	5
Auxiliary Equipment, Oil Switches and Transformers	5 to	8
Switchboard, Engines, Generators, Blowers, Compressors	6 to	10
Printing Industries		
Matrixing and Casting, Miscellaneous Machines, Presses	8 to	12
Proof Reading, Lithographing, Electrotyping	10 to	15
*Linotype, Monotype, Typesetting, Imposing Stone Engraving	25 to	100
Receiving and Shipping	4 to	6
Rubber Manufacturing and Products		
Calendars, Compounding Mills, Fabric Preparation, Stock Cutting, Tubing Machines, Solid Tire Operations, Mechanical Goods Building, Vulcanizing	8 to	12
Bead Building, Pneumatic Tire Building and Finishing, Inner Tube Operation, Mechanical Trimming, Treading	10 to	15
Sheet Metal Works		
Miscellaneous Machines, Ordinary Bench Work	8 to	12
Punches, Presses, Shears, Stamps, Welders, Spinning, Fine Bench Work	10 to	15
*Tin Plate Inspection	15 to	25
Shoe Manufacturing		
Hand Turning, Miscellaneous Bench and Machine Work	8 to	12
Inspecting and Sorting Raw Material, Cutting, Lasting and Welding (Light)	10 to	15
*Inspecting and Sorting Raw Material, Cutting, Stitching (Dark)	25 to	100
Soap Manufacturing		
Kettle Houses, Cutting, Soap Chip and Powder	5 to	8
Stamping, Wrapping and Packing, Filling and Packing Soap Powder	6 to	10
Steel and Iron Mills		
Bar, Sheet and Wire Products, Soaking Pits and Reheating Furnaces	2 to	3
Charging and Casting Floors	4 to	6
Muck and Heavy Rolling, Shearing, Rough by Gauge, Pickling and Cleaning	5 to	8
Plate Inspection, Chipping	15 to	25
Automatic Machines, Rod, Light and Cold Rolling, Wire Drawing, Shearing, Fine by Line	8 to	12
Steel Fabrication		
Girder and Truss Assembly	6 to	10
Stone, Crushing and Screening		
Belt Conveyor Tubes, Main Line Shafting, Spaces, Chute Rooms, Inside of Bins	2 to	3
Primary Breaker Room, Auxiliary Breakers under Bins	3 to	5
Screen Rooms	5 to	8
Store and Stock Rooms		
Rough Bulky Material	2 to	3
Medium or Fine Material Requiring Care	5 to	8
Sugar Grading	15 to	25
Testing		
Rough	5 to	8
Fine	10 to	15
Extra Fine Instruments, Scales	25 to	100
Textile Mills		
(Cotton)		
Opening and Lapping, Carding, Drawing-Frame, Roving, Dyeing	5 to	8
Spooling, Spinning, Drawing-in, Warping, Weaving, Quilting, Inspecting, Knitting, Slashing (over Beam End)	8 to	12
(Silk)		
Winding, Throwing, Dyeing	8 to	12
Quilling, Warping, *Weaving and Finishing		
Light Goods	10 to	15
Dark Goods	15 to	20
(Woolen)		
Carding, Picking, Washing and Combing	4 to	6
Twisting and Dyeing	6 to	10
Drawing in, Warping		
Light Goods	6 to	10
Dark Goods	10 to	15
*Weaving		
Light Goods	8 to	12
Dark Goods	12 to	20
*Knitting Machines	10 to	15
Tobacco Products		
Drying, Stripping, General	2 to	3
*Grading and Sorting	15 to	25
Toilet and Washrooms	4 to	6
Upholstering		
Automobile, Coach and Furniture	10 to	15
Warehouse	2 to	3
Woodworking		
Rough Sawing and Bench Work	5 to	8
Sizing, Planing, Rough Sanding, Medium Machine and Bench Work, Gluing, Veneering, Cooperage	8 to	12
Fine Bench and Machine Working, Fine Sanding and Finish	10 to	15

NOTE: * Indicates operations or processes in which other factors, such as the direction of light, etc., are important considerations. Our engineers will gladly give their specific recommendations for such problems.

TABLE II

Interior Conditions Which Must Be Observed

Proportion of Room	Condition of Walls and Ceiling*	Maintenance of Reflectors	Resultant Condition of Interior
RELATIVELY BROAD Width about four times ceiling height	Very Light	Very Good	Favorable
		Average	Favorable
		Poor	Average
	Fairly Light	Very Good	Favorable
		Average	Average
		Poor	Average
	Fairly Dark	Very Good	Average
		Average	Average
		Poor	Unfavorable
AVERAGE WIDTH Width about twice ceiling height	Very Light	Very Good	Favorable
		Average	Average
		Poor	Average
	Fairly Light	Very Good	Average
		Average	Average
		Poor	Unfavorable
	Fairly Dark	Very Good	Average
		Average	Unfavorable
		Poor	**Very Unfavorable
NARROW Width about equal to ceiling height	Very Light	Very Good	Average
		Average	Average
		Poor	Unfavorable
	Fairly Light	Very Good	Average
		Average	Unfavorable
		Poor	**Very Unfavorable
	Fairly Dark	Very Good	Unfavorable
		Average	**Very Unfavorable
		Poor	**Very Unfavorable

*See Table below for data from which this condition may be determined.

**It is recommended that interior room conditions be improved or provision made for more frequent maintenance.

Method of Determining Condition of Walls and Ceilings

Class	Surface	Color
Very Light	Paint	White Ivory Cream
	Caen Stone	Cream
Fairly Light	Paint	Buff Light Green Light Gray Light Blue
	Caen Stone	Gray
Fairly Dark	Paint	Tan Dark Gray Olive Green
	Wood	Light Oak Dark Oak Mahogany
	Cement	Natural
	Brick	Red

TABLE III ILLUMINATION CALCULATION

To Determine Reflector Spacing and Lamp Size:

1. Decide highest possible mounting height;
2. Locate room condition as determined in Table II;
3. Follow line horizontally to right until foot-candle intensity desired is located. Lamp and reflector size at top of column. Reflector spacing given in column at left of mounting height.

Benjamin RLM Dome Reflector

For good general illumination of average industrial interiors. Shaped to illuminate both horizontal and vertical surfaces. 17½ degree angle of cut-off protects eyes of workers against glare.

Area Per Outlet Adequately Lighted or Approximate Spacing	Distance from Underside of Reflector to Floor not to be less than	Room Conditions	Average foot-candles obtained from above reflector using lamp sizes as given at top of columns.					WATTS PER SQUARE FOOT				
			100 Watt	150 Watt	200 Watt	300 Watt	500 Watt	100 Watt	150 Watt	200 Watt	300 Watt	500 Watt
55-65 Sq. Ft. or 7¾′x7¾′ Spacing	7′ 6″	Favorable	8-10	15-18	21-26	34-40	61-72	1.7	2.5	3.3	5	8
		Average	6-8	11-15	16-21	25-34	45-61					
		Unfavorable	5.5-6.5	9-11	13-16	20-25	36-45					
65-75 Sq. Ft. or 8½′x8½′ Spacing	8′ 0″	Favorable	7-9	13-16	18-22	29-35	52-63	1.4	2.1	2.8	4	6.6
		Average	6-7	10-13	13-18	21-29	38-52					
		Unfavorable	5-6	8-10	11-13	18-21	32-38					
75-85 Sq. Ft. or 9′x9′ Spacing	8′ 6″	Favorable	6-8	11-14	15-19	24-31	43-56	1.2	1.8	2.5	3.7	6.1
		Average	5-6	8-11	12-15	19-24	34-43					
		Unfavorable	4-5	7-8	10-12	16-19	29-34					
85-95 Sq. Ft. or 9½′x9½′ Spacing	9′ 0″	Favorable	5-7	10-12	14-17	22-27	39-48	1.1	1.7	2.2	3.3	5.5
		Average	4-5	8-10	11-14	18-22	32-39					
		Unfavorable	3.5-4.0	6-8	9-11	14-18	25-32					
95-110 Sq. Ft. or 10′x10′ Spacing	9′ 6″	Favorable	4-6	8-10	12-15	21-26	38-47	1	1.5	2	3	5
		Average	3.5-4.0	6-8	10-12	16-21	29-38					
		Unfavorable	3.0-3.5	5-6	8-10	13-16	23-29					
110-125 Sq. Ft. or 11′x11′ Spacing	10′ 0″	Favorable	4-5	7-9	10-13	18-22	32-39	.8	1.2	1.6	2.5	4.1
		Average	3.5-4.0	6-7	8-10	14-18	25-32					
		Unfavorable	2.5-3.5	5-5.5	7-8	12-14	21-25					
125-145 Sq. Ft. or 11½′x11½′ Spacing	10′ 6″	Favorable	3.5-4.0	6-8	9-11	15-19	27-34	.7	1.1	1.5	2.3	3.7
		Average	3.0-3.5	5-6	7-9	12-15	21-27					
		Unfavorable	2.5-3.0	4-5	6-7	10-12	18-21					
145-170 Sq. Ft. or 13′x13′ Spacing	11′ 6″	Favorable	3.0-3.5	5-7	7-9	13-17	23-30	.6	1	1.3	1.9	3.2
		Average	2.5-3.0	4-5	6-7	10-13	18-23					
		Unfavorable	2.0-2.5	3.5-4.0	5-6	8-10	14-18					
170-200 Sq. Ft. or 13½′x13½′ Spacing	12′ 0″	Favorable	2.5-3.5	4-6	6-8	11-14	20-25	.6	.8	1.1	1.6	2.7
		Average	2.0-3.0	3.5-4.0	5-6	8-11	16-20					
		Unfavorable	1.5-2.0	3.0-3.5	4-5	7-8	13-16					
200-230 Sq. Ft. or 14¾′x14¾′ Spacing	12′ 6″	Favorable	2.5-3.0	3.5-4.0	5-7	10-12	17-22	.5	.7	.9	1.4	2.3
		Average	2.0-2.5	3.0-3.5	4.5-5.5	7-10	13-17					
		Unfavorable	1.0-1.5	2.5-3.0	3.5-4.0	6-7	11-13					
230-260 Sq. Ft. or 15½′x15½′ Spacing	13′ 0″	Favorable	.....	3.0-3.5	4-6	8-10	15-19	.....	.6	.8	1.2	2.1
		Average	.....	2.5-3.0	4-4.5	6-8	12-15					
		Unfavorable	.....	2.0-2.5	3.5-4.0	5.5-6.5	10-12					
260-300 Sq. Ft. or 16¾′x16¾′ Spacing	13′ 6″	Favorable	.....	2.5-3.0	4-5	7-9	13-17	.....	.5	.7	1.1	1.7
		Average	.....	2.0-2.5	3.5-4.0	6-7	10-13					
		Unfavorable	.....	1.5-2.0	3.0-3.5	5-6	9-10					
300-340 Sq. Ft. or 18′x18′ Spacing	14′ 6″	Favorable	.....	.....	3.5-4.0	6-8	12-14	.....	.....	.6	.9	1.5
		Average	.....	.....	3.0-3.5	5-6	9-12					
		Unfavorable	.....	.....	2.5-3.0	4-5	7-9					
340-390 Sq. Ft. or 19′x19′ Spacing	15′ 6″	Favorable	.....	.....	3.0-3.5	5-7	10-12	.....	.....	.5	.8	1.4
		Average	.....	.....	2.5-3.0	4-5	7-10					
		Unfavorable	.....	.....	2.0-2.5	3.5-4.0	6-7					
390-440 Sq. Ft. or 20½′x20½′ Spacing	16′ 6″	Favorable	.....	.....	2.5-3.0	4-6	9-11	.....	.....	.4	.7	1.2
		Average	.....	.....	2.0-2.5	3.5-4.0	7-9					
		Unfavorable	.....	.....	1.5-2.0	3.0-3.5	5-6					
440-500 Sq. Ft. or 21¾′x21¾′ Spacing	17′ 0″	Favorable	.....	.....	.....	4-5	8-10	.....	.....	.....	.6	1
		Average	.....	.....	.....	3.0-3.5	6-8					
		Unfavorable	.....	.....	.....	2.5-3.0	4-5					

NOTE: Between wall and first row of fixtures use ½ above fixture spacing, except where workbenches are next to the wall. In such cases shorten this space from 1 to 2 feet, depending on circumstances.
NOTE: Intensities shown above are obtained by using White Bowl Lamps.

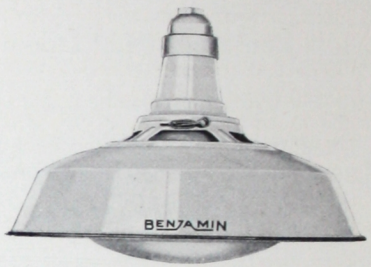
TABLE III ILLUMINATION CALCULATION

To Determine Reflector Spacing and Lamp Size:

1. Decide highest possible mounting height;
2. Locate room condition as determined in Table II:
3. Follow line horizontally to right until foot-candle intensity desired is located. Lamp and reflector size at top of column. Reflector spacing given in column at left of mounting height.

Benjamin Glassteel Diffuser

For very best general illumination of average industrial interiors. Gives a soft, evenly diffused light on both working plan and ceiling, eliminating harsh shadows, relieving contrast, and giving the room a bright, cheerful appearance.

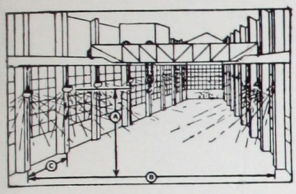


Area Per Outlet Adequately Lighted or Approximate Spacing	Distance from Underside of Reflector to Floor not to be less than	Room Conditions	Average foot-candles obtained from above reflector using lamp sizes as given at top of columns.					WATTS PER SQUARE FOOT				
			100 Watt	150 Watt	200 Watt	300 Watt	500 Watt	100 Watt	150 Watt	200 Watt	300 Watt	500 Watt
55-65 Sq. Ft. or 7¾′x7¾′ Spacing	7′ 6″	Favorable	.....	13-16	18-23	29-37	52-66	.....	2.5	3.3	5	8
		Average	.....	10-13	14-18	23-29	41-52					
		Unfavorable	.....	8-10	11-14	18-23	32-41					
65-75 Sq. Ft. or 8½′x8½′ Spacing	8′ 0″	Favorable	.....	11-14	15-19	24-31	43-56	.....	2.1	2.8	4	6.6
		Average	.....	8-11	11-15	18-24	32-43					
		Unfavorable	.....	7-8	9-11	14-18	25-32					
75-85 Sq. Ft. or 9′x9′ Spacing	8′ 6″	Favorable	.....	10-12	13-17	21-27	38-48	.....	1.8	2.5	3.7	6.1
		Average	.....	8-10	10-13	16-21	29-38					
		Unfavorable	.....	6-8	8-10	13-16	23-29					
85-95 Sq. Ft. or 9½′x9½′ Spacing	9′ 0″	Favorable	.....	8-10	12-15	19-26	34-47	.....	1.7	2.2	3.3	5.5
		Average	.....	6-8	9-12	14-19	25-34					
		Unfavorable	.....	5-6	7-9	11-14	20-25					
95-110 Sq. Ft. or 10′x10′ Spacing	9′ 6″	Favorable	.....	7-9	11-13	18-23	32-41	.....	1.5	2	3	5
		Average	.....	5-7	8-11	13-18	23-32					
		Unfavorable	.....	4-5	6-8	11-13	20-23					
110-125 Sq. Ft. or 11′x11′ Spacing	10′ 0″	Favorable	.....	6-8	9-11	15-19	27-34	.....	1.2	1.6	2.5	4.1
		Average	.....	5-6	7-9	11-15	20-27					
		Unfavorable	.....	4-5	5-6	9-11	16-20					
125-145 Sq. Ft. or 11½′x11½′ Spacing	10′ 6″	Favorable	.....	5-7	8-10	13-17	23-30	.....	1.1	1.5	2.3	3.7
		Average	.....	4-5	6-8	10-13	18-23					
		Unfavorable	.....	3-4	4.5-5.5	8-10	14-18					
145-170 Sq. Ft. or 13′x13′ Spacing	11′ 6″	Favorable	.....	4-6	6.5-8	12-15	21-26	.....	1.	1.3	1.9	3.2
		Average	.....	3-4	5-6	9-12	16-21					
		Unfavorable	2.5-3.5	4-5	7-9	13-16						
170-200 Sq. Ft. or 13½′x13½′ Spacing	12′ 0″	Favorable	.....	3.5-5.0	6-7	10-12	18-23	.....	.8	1.1	1.6	2.7
		Average	.....	3.0-3.8	4-5	7-10	13-18					
		Unfavorable	.....	2.5-3.0	3.5-4.0	6.5-7.5	10-13					
200-230 Sq. Ft. or 14¾′x14¾′ Spacing	12′ 6″	Favorable	.....	3.5-4.0	5-6	8-10	15-19	.....	.7	.9	1.4	2.3
		Average	.....	2.8-3.5	3.5-4.0	6.5-8	11-15					
		Unfavorable	.....	2.0-2.5	3.0-3.5	5.5-6.5	9-11					
230-260 Sq. Ft. or 15½′x15½′ Spacing	13′ 0″	Favorable	.....	3.0-3.5	4-5	7.5-9	13-17	.....	.6	.8	1.2	2.1
		Average	.....	2.5-3.0	3-4	6-7	10-13					
		Unfavorable	.....	1.5-2.0	2.5-3.0	4.5-5.5	8-10					
260-300 Sq. Ft. or 16¾′x16¾′ Spacing	13′ 6″	Favorable	.....	2.5-3.0	3.5-4.0	7-8	12-15	.....	.5	.7	1.1	1.7
		Average	.....	2.0-2.6	3.0-3.5	5-6	9-12					
		Unfavorable	.....	.....	2.0-2.5	4-4.5	7-9					
300-340 Sq. Ft. or 18′x18′ Spacing	14′ 6″	Favorable	.....	.....	3.0-3.5	5-7	10-12	.....	.....	.6	.9	1.5
		Average	.....	.....	2.5-3.0	4-5	8-10					
		Unfavorable	.....	.....	1.5-2.0	3.5-4.0	6-8					
340-390 Sq. Ft. or 19′x19′ Spacing	15′ 6″	Favorable	.....	.....	2.5-3.0	4.5-6	9-11	.....	.....	.5	.8	1.4
		Average	.....	.....	2.0-2.5	3.5-4.0	7-9					
		Unfavorable	.....	.....	.....	3.0-3.5	5.5-6.5					
390-440 Sq. Ft. or 20½′x20½′ Spacing	16′ 6″	Favorable	.....	.....	.....	4-5	8-10	.....	.....	.....	.7	1.2
		Average	.....	.....	.....	3-4	6-8					
		Unfavorable	.....	.....	.....	2.5-3.0	5-6					
440-500 Sq. Ft. or 21¾′x21¾′ Spacing	17′ 0″	Favorable	.....	.....	.....	3.5-4.0	6-8	.....	.....	.....	.6	1
		Average	.....	.....	.....	2.5-3.5	5-6					
		Unfavorable	.....	.....	.....	2.0-2.5	4-5					

NOTE: Between wall and first row of fixtures use ½ above fixture spacing, except where workbenches are next to the wall. In such cases shorten this space from 1 to 2 feet, depending on circumstances.

Illumination Calculation

To Determine Reflector Spacing and Lamp Size:



1. Decide highest possible mounting height of reflectors;
2. (In column B opposite mounting height decided on) locate maximum width of room which can be lighted without the addition of overhead units;
3. Follow line horizontally to right until foot-candle intensity desired is located. Lamp and reflector size at top of column. Reflector spacing given in Column C at left.

NOTE: If the distance across room (B) is less than twice the mounting height (A), no overhead lights will be needed except to secure higher intensities, provide exceptionally good lighting on horizontal surfaces, or to illuminate space above crane rails.

If the distance across room (B) is greater than twice the mounting height (A), deduct one half of dimension B from the room width. Treat this remaining area as a separate room (in the center of the building) and use spacing dimensions given for overhead reflectors. In R. L. M. Standard Dome intensity charts, select lamp size and spacing which provides an intensity equal to that obtained from elliptical angle reflectors.

Benjamin Elliptical Angle Reflector

The elliptical angle is especially shaped for those locations where lighting must come from the side; for example, in construction shops where there are traveling cranes overhead, also in narrow buildings with very high ceilings where it is not necessary to light the upper areas. Also excellent for the lighting of vertical surfaces.

A Mounting Height Above Floor	B Maximum Distance Across Room	C Spacing Distance Between Reflectors	Size of Lamp and Degree of Illumination in Foot Candles						
			100 Watt	150 Watt	200 Watt	300 Watt	500 Watt	750 Watt	1000 Watt
12′ 6″	20′	10′	4½	8	11	18	32	52	69
15′	25′	12′ 6″	3	5½	7½	12	22	35	46
17′	30′	15′	.....	3½	5	8	14	23	31
20′	35′	17′ 6″	.....	2½	3¾	6	11	17	23
22′ 6″	40′	20′	.....	.....	2¾	4½	8	13	17
25′	45′	22′ 6″	.....	.....	.....	3½	6½	10	13
27′ 6″	50′	25′	.....	.....	.....	3	5½	8½	11
30′	55′	27′ 6″	.....	.....	.....	2½	4½	7	10
32′ 6″	60′	30′	.....	.....	.....	.....	3½	6	8
37′ 6″	70′	35′	.....	.....	.....	.....	2½	4½	6
42′ 6″	80′	40′	.....	.....	.....	.....	.....	2½	4½

NOTE: Under crane ways mount reflectors as close to rails as necessary clearance will permit.

Illumination Calculation

To Determine Reflector Spacing and Lamp Size:

1. Decide on mounting height, allowing for clearance of all ceiling obstructions.
2. Keeping maximum width of room in mind, locate in chart opposite mounting height decided upon, the number of rows of units required.
3. Locate desired foot candle value shown under required mounting height and number of rows of units necessary. Then over to the left under column headed "Approximate Spacing" note the spacing recommendations given.

NOTE: Where two or more spacing distances may be used to obtain the same foot candle value, use the closest recommended spacing to secure the best lighting results.

Benjamin Concentrating Type Unit

The Benjamin Concentrating Type High Mounting Unit is suitable for installation where the mounting height is equal to or greater than the width of the room to be lighted. It is very effective in lighting comparatively narrow rooms where not more than three rows of units are required.

Mounting Height	Number of Rows of Units	Approx. Spacing, Feet	Approx. Area (Square Feet) Lighted By Each Unit	Foot Candles (Approximate for Average Room Conditions) Lamp Size (Clear Lamps)		
				750 Watt	1000 Watt	1500 Watt
35′ Max. Room Width 35′	One Row of Units	20	400	18.5	25.5	42.0
		25	625	12.0	16.5	26.0
		30	900	8.5	11.5	18.5
		35	1200	6.0	8.5	14.0
35′ Max. Room Width 70′	Two Rows of Units	25 x 25	625	14.0	19.0	31.0
		25 x 30	750	11.5	16.0	26.0
		30 x 30	900	9.5	13.0	21.5
		35 x 35	1200	7.0	10.0	16.5
35′ Max. Room Width 105′	Three Rows of Units	25 x 25	625	14.5	20.0	33.5
		25 x 30	750	12.0	17.0	28.0
		30 x 30	900	10.0	14.0	23.0
		35 x 35	1200	7.5	10.5	17.5
45′ Max. Room Width 45′	One Row of Units	25	625	11.5	16.0	24.0
		30	900	8.0	11.0	18.0
		35	1200	6.0	8.0	13.5
		40	1600	4.5	6.5	10.5
		45	2000	....	5.0	8.5
45′ Max. Room Width 90′	Two Rows of Units	25 x 30	750	11.0	15.5	25.5
		30 x 30	900	9.5	13.0	21.5
		35 x 35	1200	7.0	10.0	16.0
		40 x 40	1600	5.5	7.5	12.0
		45 x 45	2000	4.0	6.0	9.5
55′ Max. Room Width 55′	One Row of Units	30	900	8.0	11.0	18.5
		35	1200	6.0	8.0	13.5
		40	1600	4.5	6.0	10.0
		45	2000	....	5.0	8.0
		50	2500	....	4.0	6.5
55′ Max. Room Width 110′	Two Rows of Units	30 x 30	900	9.0	12.5	21.0
		35 x 35	1200	7.0	9.5	15.5
		40 x 40	1600	5.0	7.0	12.0
		45 x 45	2000	4.0	6.0	9.5
		50 x 50	2500	....	....	7.5

NOTE: In indoor locations the use of Benjamin Dust Tight Covers on Benjamin Concentrating Type Units is always recommended as a means of keeping lighting equipment at maximum efficiency.

NOTE: When Benjamin Dust Tight Covers are used, the initial foot candle values given in the table above will be approximately 15% less.